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ABSTRACT

This document is one of a series of modules in the Missouri Auto Mechanics Curriculum Guide, which is based on 144 basic auto mechanics competencies identified on the Missouri Auto Mechanics Competency Profile. The instructor's materials in this document are for a 13-unit secondary education course. The following units are included: (1) introduction to manual drive train and axle design; (2) manual transmission components and their operation; (3) manual transmission diagnosis and repair; (4) components of the clutch assembly and how they operate; (5) clutch assembly, diagnosis, and repair; (6) drive shaft diagnosis and repair; (7) differential components and their operation; (8) differential diagnosis and removal; (9) differential repair, installation, and performance testing; (10) manual transaxle operation and diagnosis; (11) manual transaxle repair, installation, and performance testing; (12) four-wheel drive operation, diagnosis, and repair; and (13) transfer case diagnosis and repair. The document begins with explanations of how to use the curriculum guide, how and why student achievement of competencies is evaluated over several job sheets, and how the curriculum guide is packaged. Next is a table that associates individual instructional materials in the units with the competencies they teach. The instructional units include unit objectives, objectives specific to each lesson in the unit, references, information sheets or outlines, assignment sheets, job sheets, tests, and answers to tests. (CML)

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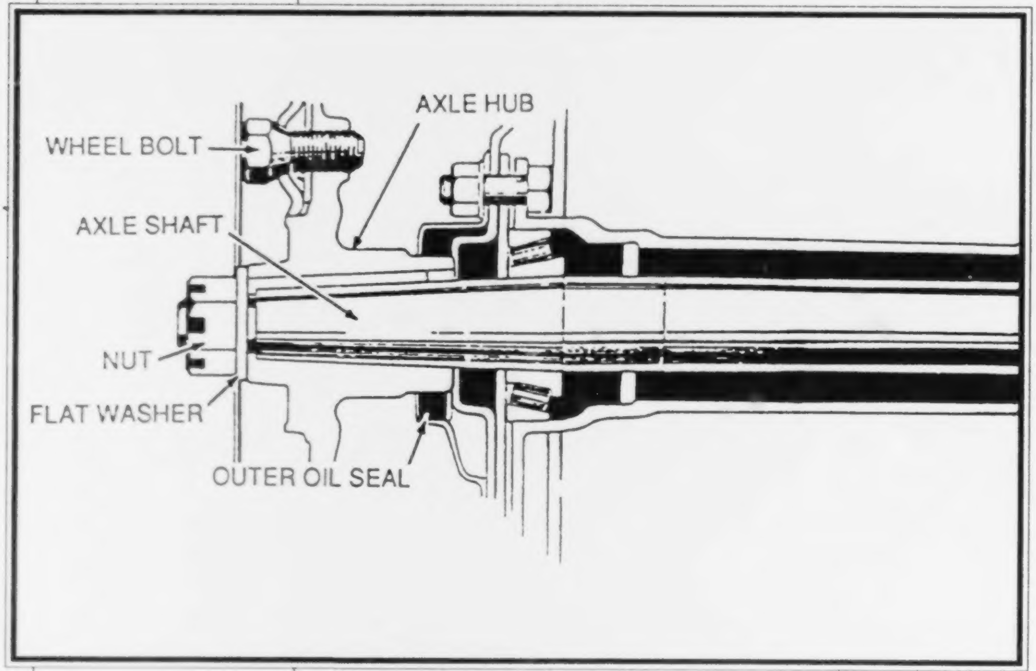
Instructor's Guide

Auto Mechanics
Curriculum Guide



Module 7
Manual Drive Train And Axles

Produced by
Instructional Materials Laboratory
In cooperation with the Dept. of
Elementary and Secondary
Education

CE 054 321

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MODULES INCLUDED IN THE AUTO MECHANICS CURRICULUM GUIDE

INTRODUCTION TO AUTO MECHANICS
ELECTRICAL SYSTEMS
ENGINE PERFORMANCE
ENGINE REPAIR
SUSPENSION AND STEERING
BRAKES
MANUAL DRIVE TRAIN AND AXLES
AUTOMATIC TRANSMISSION AND TRANSAXLES
HEATING AND AIR CONDITIONING

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AUTO MECHANICS CURRICULUM

MODULE 7: MANUAL DRIVE TRAIN AND AXLES

INSTRUCTOR'S GUIDE

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The Manual Drive Train and Axles Module (the seventh of nine modules to make up the Missouri Auto Mechanics Curriculum Guide) is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. Job sheets within the guide evaluate specific competencies and can be managed with the Vocational Administrative Management System (VAMS). All major components of the module have been keyed to the Missouri Auto Mechanics Competency Profile, which was developed by industry and education professionals within Missouri.

Special appreciation is given to Robert Colesworthy, who was the primary writer for this module. Special appreciation is also given to Roger Donovan, who served as both a technical adviser and writer during production of the module.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both teacher and student. Any future auto mechanics curriculum modifications will begin with the Missouri Auto Mechanics Curriculum Guide. Auto mechanics, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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Manual Drive Train and Axles is the seventh of nine modules that make up the Missouri Auto Mechanics Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). All modules in the guide are based on the Missouri Auto Mechanics Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technologically advanced field of auto mechanics.

IML extends special recognition to Robert Colesworthy, the primary writer of Manual Drive Train and Axles. Mr. Colesworthy's thorough knowledge of automotive technology and years of teaching experience are evident throughout his work. Special recognition also goes to Roger Donovan, who contributed heavily to the module, both as a writer and technical advisor. Mr. Donovan's attention to technical detail proved invaluable throughout the module's development.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

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IML also acknowledges the fieldtesters, who worked to ensure that the Manual Drive Train and Axles Module was developed into an effective and practical teaching tool. The fieldtesters are listed below:

Fieldtesters
Robert Barbarick, Four Rivers AVTS, Washington, Mo.
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The support and contributions of the following IML staff members were instrumental in the development of this module:

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Lori Holliday, Word Processor Operator III
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CONTENTS OF THE MANUAL DRIVE TRAIN AND AXLES MODULE

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UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION . . . MDT 23

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR . . . . MDT 67

UNIT IV: COMPONENTS OF THE CLUTCH ASSEMBLY AND HOW THEY OPERATE . . MDT 115

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR . . . . MDT 143

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR . . . . MDT 171

UNIT VII: DIFFERENTIAL COMPONENTS AND THEIR OPERATION . . . . MDT 203

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL . . . . MDT 237

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UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS . . . . MDT 285

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING . . . . MDT 321

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR . . . . . MDT 373

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR . . . . MDT 409

HOW TO USE THE MISSOURI AUTO MECHANICS CURRICULUM GUIDE

Every module of the Missouri Auto Mechanics Curriculum Guide contains the following seven major components: (1) a competency profile, (2) objective sheets, (3) information sheets, (4) assignment sheets, (5) tests, (6) job sheets, and (7) a cross-reference table. Below is a discussion of the design of these components.

MISSOURI COMPETENCY PROFILE

The competency profile identifies 144 basic auto mechanics competencies. The profile divides the competencies into nine general areas, each of which serves as the basis for individual modules of instruction (such as the Manual Drive Train and Axles Module). The competency profile further divides these general areas into duty bands, each of which is identified by a capital letter. An example of a duty band in the Manual Drive Train and Axles Module would be "Manual Transmission/Transaxle Diagnosis and Repair." Under each duty band are listed several competencies, each of which is identified by an Arabic numeral. Note the below excerpt from the competency profile:

3	2	1	N	Aa	Manual Transmission/Transaxle Diagnosis and Repair	ASE Task(s)
				1	Diagnose, performance test, and determine needed repair	C001 C011 C022
				2	Remove, disassemble, inspect, and clean manual transmission/transaxle and shift linkages	C012 C013 C015 C017
				3	Reassemble manual transmission/transaxle assembly, check end play and adjustments	C018 C026 C028 C045

In this excerpt, the duty band "Manual Transmission/Transaxle Diagnosis and Repair" is identified by the letters "Aa." The competency "Reassemble manual transmission/transaxle assembly, check end-play and adjustments" falls under Duty Band Aa and is identified by the Arabic numeral "3." Throughout the Auto Mechanics Curriculum Guide, therefore, the competency "Reassemble manual transmission/transaxle assembly, check end-play and adjustments" will be referred to as Competency Aa3.

Also note that one or more ASE tasks are listed to the right side of each competency on the profile. These ASE tasks are directly related to those competencies by which the tasks appear.

(**NOTE**: The term "cross-reference table" will appear throughout the rest of this discussion. A cross-reference table is a chart that shows precisely how objectives, assignment sheets, test questions, and job sheets are related to individual competencies. The cross-reference table will be discussed later in more detail.)

INFORMATION SHEETS

The information sheets (or information outline) present the student with important facts and concepts relating to basic automotive technology and service procedures. The information sheets also explain why a procedure is necessary and why it must be performed in a certain manner. Though not intended to be as comprehensive as a text book, the information sheets provide a good source of information to which the student can refer outside of class. Perhaps the information sheets can best be thought of as a thorough set of notes accompanying the instructor's classroom lecture.

ASSIGNMENT SHEETS

The assignment sheets serve one of two functions: they can either emphasize important cognitive information or instruct students in developing procedures specific to a particular vehicle. The "Notes to the Instructor," found on the table of contents section of each module, indicates how each assignment sheet is used.

(**NOTE**: Assignment sheets are not used to evaluate competencies directly. Only job sheets directly evaluate competencies.)

UNIT TESTS

Unit tests cover information relating to specific competencies. The student must obtain acceptable test scores (decided upon by the instructor) before receiving an evaluation for these competencies. (Since job sheets are used to evaluate competencies, the student, therefore, must receive an acceptable test score before doing certain job sheets.) The test ensures that the student has the minimum knowledge required to perform the competencies covered on the job sheets. On some tests, all the questions cover information that relates equally to a single competency or a group of competencies. At the end of these tests, a note like the following appears:

> (NOTE: The student must obtain a minimum score of ____ on the Unit VIII Test in order to receive an evaluation for Competency Cc1.)

On other tests, one group of questions covers information related exclusively to one particular competency while another group of questions relates exclusively to another particular competency. Questions relating to an individual competency (or a group of specific competencies) are divided into parts. At the end of each part, a note like the following appears:

> (NOTE: The student must obtain a minimum score of _____ on Part III of the Unit III Test in order to receive an evaluation for Competency Aa1.)

All the job sheets and test questions related to each competency are listed on the module's cross-reference table. The cross-reference table allows the instructor to determine what unit tests (or what parts of unit tests) a student must successfully complete before being eligible to perform the job sheets related to a particular competency. By observing the end-of-test notes and using the cross-reference table, the instructor can easily determine what job sheets a student is eligible to do as a result of his or her score on a particular test or part of a test.

The beginning units of a module often deal with basic knowledge that relates generally to all competencies in a module. The tests for these units will have notes stating that the student must obtain a certain score before performing any competencies in the module.

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OBJECTIVE SHEETS

The first page of each unit in the guide is an objective sheet, which states the unit's general and specific objectives. Below is the objective sheet for Unit VIII of the Manual Drive Train and Axles Module:

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose a differential and remove it from the vehicle. The student will demonstrate mastery of the material by achieving a score of ___ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student will be able to:

Lesson 1. I. Identify safety precautions for rear axle diagnosis and removal (Competency Cc1, Unit VIII Test).

II. Identify problems that do not require differential removal (Competency Cc1, Unit VIII Test).

III. Identify problems requiring differential removal (Competency Cc1, Unit VIII Test).

IV. Demonstrate the ability to:

a. Diagnose differential problems (Competency Cc1, JS1-L1-UVIII).

Lesson 2. I. Identify procedures for in-vehicle differential repairs (Competency Cc1, Unit VIII Test).

II. Identify procedures for differential removal (Competency Cc1, Unit VIII Test).

ASE TASKS COVERED IN THIS UNIT

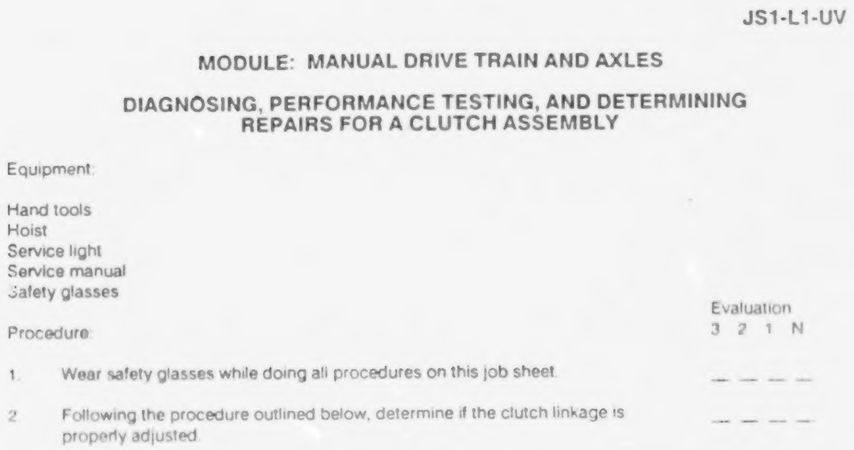
I. The job sheet in this unit covers ASE tasks C051, C062, C066.

Notice that the specific objectives are designated by Roman numerals. Also notice that the competency (or competencies) to which each objective relates is listed in parentheses behind each objective. Also listed in parentheses is the method by which the objective is evaluated.

A note identifying the ASE tasks that are covered by the unit's job sheets appears at the end of every objective sheet.

JOB SHEETS

Besides giving the student practical, hands-on experience in auto mechanics, job sheets provide a means of evaluating a student's ability to perform the competencies. The job sheets are, therefore, the key component of the Missouri Auto Mechanics Curriculum Guide. Below is an excerpt from the first page of a typical job sheet in the Manual Drive Train and Axles Module:



JS1-L1-UV

MODULE: MANUAL DRIVE TRAIN AND AXLES

DIAGNOSING, PERFORMANCE TESTING, AND DETERMINING
REPAIRS FOR A CLUTCH ASSEMBLY

Equipment:

Hand tools
Hoist
Service light
Service manual
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2.	Following the procedure outlined below, determine if the clutch linkage is properly adjusted.	___ ___ ___ ___

Notice that the job sheet is identified as JS1-L1-UV, which translates into Job Sheet 1, Lesson 1, Unit V. This shorthand system of job sheet identification is used throughout the curriculum guide.

(**NOTE:** Assignment sheets are identified with the same shorthand system. Assignment Sheet 1, Lesson 1, Unit X would be AS1-L1-UX.)

(**NOTE:** Both job sheets and assignment sheets are numbered consecutively within unit lessons.)

Also notice that, in the above job sheet excerpt, the spaces to the right of the page allow the instructor to evaluate the student on a particular job sheet activity. These spaces appear only by numbered items, which represent significant tasks; therefore, the instructor is freed from having to evaluate the minor steps of a procedure. At the beginning of each job sheet the heading "3 2 1 N" indicates the four possible evaluations a student can receive. The meaning of the numbers and the letter N is as follows:

3 = Mastered - can work independently with no supervision
2 = Requires Supervision - can perform job completely with limited supervision
1 = Not Mastered - requires instruction and close supervision
N = No Exposure - no experience or knowledge in this area

The individual evaluations made throughout a job sheet are averaged together at the end of the job sheet. A note at the end of the job sheet explains how this average relates to the final evaluation for a particular competency. In the below example taken from JS1-L1-UVIII, a note explains that the average of the individual evaluations (made throughout JS1-L1-UVIII) is the final evaluation for Competency Cc1:

Average of above evaluations* ____

(*This is the final evaluation for Competency Cc1)

As automotive instructors know, an automobile contains many complex and interrelated components. A single general service task may involve several different procedures. In the Missouri Auto Mechanics Curriculum Guide, therefore, a competency may be evaluated over several job sheets; also one job sheet may evaluate several competencies. As will be demonstrated later, each job sheet is accompanied by a thorough set of instructions, explaining how each of the final job sheet averages is to be used. The cross-reference table is also quite helpful in showing which job sheets evaluate which competencies.

CROSS-REFERENCE TABLE

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items. Note the following excerpt from the Manual Drive Train and Axles cross-reference table:

MODULE: MANUAL DRIVE TRAIN AND AXLES
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Aa3	UIII-L3-I, UIII-L3-II, UIII-L3-III, UIII-L3-IV, UIII-L3-V-a, UIII-L3-V-b, UX-L1-I, UX-L1-II, UX-L1-III, UXI-L2-III, UXI-L2-V-c, UXI-L3-I, UXI-L3-II, UXI-L3-III-a	AS1-L3-UIII, AS1-L2-UX, AS2-L2-UXI, AS1-L3-UXI	JS1-L3-UIII, JS2-L3-UIII, JS3-L2-UXI, JS1-L3-UXI	Part II of Unit III Test, Part I of Unit X Test, Part II of Unit XI Test

The above excerpt lists all the instructional objectives in the module that cover Competency Aa3. The cross-reference table also indicates the parts of the various unit tests that cover Competency Aa3. Just as importantly, the table reveals at a glance that the student must perform JS1-L3-UIII, JS2-L3-UIII, JS3-L2-UXI, and JS1-L3-UXI before he or she can receive an evaluation for Competency Aa3. By looking at the cross-reference table, the instructor can, therefore, quickly determine what test questions a student needs to answer and what job sheets a student needs to perform before receiving a final evaluation for a particular competency.

HOW AND WHY COMPETENCIES ARE EVALUATED OVER SEVERAL JOB SHEETS

According to the competency profile, Competency Aa3 ("Reassemble manual transmission/transaxle assembly, check end-play and adjustments") covers 27 ASE tasks. A job sheet covering all of these ASE tasks would be unreasonably long and overly complicated. The Missouri Auto Mechanics Curriculum Guide, therefore, allows the student to perform several job sheets in order to receive an evaluation on Competency Aa3. These job sheets are listed below:

JS1-L3-UIII	Reassembling a Manual Transmission
JS2-L3-UIII	Reinstalling and Adjusting a Manual Transmission
JS3-L2-UXI	Reassembling a Manual Transaxle
JS1-L3-UXI	Reinstalling and Adjusting a Manual Transaxle

The activities in the above job sheets satisfy Missouri Competency Aa3 and the ASE tasks that accompany Aa3. At the end of each job sheet relating to Aa3, a note explains that the individual evaluations made throughout the job sheet averaged together to determine a partial evaluation for Aa3. The note also indicates on what job sheet the final evaluation for Aa3 will be determined. Below is an example of the note:

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa3. Final evaluation for Aa3 will be made at the end of JS1-L3-UXI.)

At the end of JS1-L3-UXI, the following notes and directions explain how and where the final evaluation for Aa3 is to be made:

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa3. Final evaluation will be made below.)

FINAL EVALUATION INSTRUCTIONS

1. Determine the student's final evaluation for Competency Aa3 by averaging the final evaluation of JS1-L3-UIII, JS2-L3-UIII, JS3-L2-UXI, and JS1-L3-UXI. Use the spaces provided below.

JS1-L3-UIII — — — —

JS2-L3-UIII — — — —

JS3-L2-UXI — — — —

JS1-L3-UXI — — — —

Final evaluation for Competency Aa3 — — — —

The content of the Manual Drive Train and Axles Module is organized in the most teachable manner possible; therefore, content relating to transmissions is covered in Unit III of the module while content relating to transaxles is covered in Unit XI. Because Competency Aa3 and its accompanying ASE tasks deal with reassembling and making end-play adjustments on both transmissions and transaxles, the job sheets evaluating these competencies appear in both Unit III and Unit XI.

While most job sheet notes have the same basic form, some variations do occur. For example, a job sheet such as JS1-L3-UVI, "Servicing a Drive Shaft," may evaluate several competencies. At the end of JS1-L3-UVI, the following note and evaluation instructions appear:

(*This average is a partial evaluation for Competency Bb1 and the final evaluation for Competency Bb3. Final evaluation for Bb1 will be made at the end of JS1-L2-UX.)

Though variations on job sheet notes are sometimes necessary, the information in the note is always presented in a straight-forward, easy-to-understand manner.

PACKAGING OF THE AUTO MECHANICS CURRICULUM GUIDE

Each module in the Auto Mechanics Curriculum Guide is packaged in three components: an instructor's guide, a student reference, and student work sheets. The instructor's guide includes the following items, all of which are color coded:

Cross-reference table (color-coded white)
Objective sheets (color-coded white)
Table of contents, references, notes to the instructor (color-coded pink)
Information sheets (color-coded green)
Assignment sheets (color-coded tan)
Job sheets (color-coded blue)
Unit tests (color-coded yellow)

The student reference contains copies of the objective sheets and information sheets from the instructor's guide. The student work sheets include consumable items from the instructor's guide, such as job sheets, assignment sheets, and unit tests. For convenience, the page numbers of the items in the student reference and in the work sheets are the same as those in the instructor's guide; therefore, page numbers in the student reference and work sheets are not consecutive. (Both the instructor's guide and the work sheets are color coded. All student reference pages, however, are white.)

Competency profiles for the guide are packaged in groups of ten along with a copy of the ASE task list.

Competency	Instructional Objective		Job Sheet	Test Item	Notes
Cc1	UVII-L1-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UVII-L1-V, UVIII-L1-I, UVIII-L1-II, UVIII-L1-III, UVIII-L1-IV-a, UVIII-L2-I, UVIII-L2-II		JS1-L1-UVIII	Unit VII Test, Unit VIII Test	
Cc2	UVII-L1-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UVII-L1-V, UIX-L1-I, UIX-L1-II, UIX-L1-III, UIX-L2-IV-a	AS1-L2-UIX, AS2-L2-UIX	JS1-L2-UIX	Unit VII Test, Part I of Unit IX Test	
Cc3	UVII-L1-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UVII-L1-V, UIX-L2-I, UIX-L2-II, UIX-L2-III, UIX-L2-IV-a	AS1-L2-UIX, AS2-L2-UIX	JS1-L2-UIX	Unit VII Test, Part II of Unit IX Test	
Dd1	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXII-L2-IV, UXII-L2-VI-a, UXIII-L1-I, UXIII-L1-II, UXIII-L2-I, UXIII-L2-II, UXIII-L2-III, UXIII-L4-II, UXIII-L4-III-a		JS1-L2-UXII, JS1-L4-UXIII	Unit XII Test, Parts I and II of Unit XIII Test	
Dd2	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXIII-L1-I, UXIII-L1-II, UXIII-L3-I, UXIII-L3-II, UXIII-L4-III-b	AS1-L4-UXIII	JS2-L4-UXIII	Unit XII Test, Parts I and III of Unit XIII Test	
Dd3	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXIII-L1-I, UXIII-L1-II, UXIII-L3-III, UXIII-L3-IV, UXIII-L4-I, UXIII-L4-III-b	AS2-L4-UXIII	JS2-L4-UXIII	Unit XII Test, Parts I and IV of Unit XIII Test	
Dd4	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXII-L2-III, UXII-L2-IV, UXII-L2-V, UXII-L2-VI-a	AS1-L2-UXII	JS1-L2-UXII	Unit XII Test	
Dd5	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXII-L2-III, UXII-L2-IV, UXII-L2-V,UXII-L2-VI-b	AS1-L2-UXII	JS2-L2-UXII	Unit XII Test	

MODULE: MANUAL DRIVE TRAIN AND AXLES
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
All competencies in Manual Drive Train and Axles Module	UI-L1-I, UI-L1-II, UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UII-L2-V, UII-L2-VI			Unit I Test, Unit II Test	
Aa1	UIII-L1-I, UIII-L1-II, UIII-L1-III-a, UIII-L2-I, UIII-L2-II, UX-L1-I, UX-L1-II, UX-L1-III, UX-L2-I, UX-L2-III-a	AS2-L2-UIII, AS1-L2-UX	JS1-L1-UIII, JS1-L2-UX	Part III of Unit III Test, Part I of Unit X Test, Part II of Unit X Test	
Aa2	UIII-L2-III, UIII-L2-IV, UIII-L2-V, UIII-L2-VI, UIII-L2-VII, UIII-L2-VIII, UIII-L2-IX-a, UIII-L2-IX-b, UX-L1-I, UX-L1-II, UX-L1-III, UXI-L1-I, UXI-L1-II, UXI-L1-III, UXI-L1-IV-a, UXI-L2-I, UXI-L2-V-a	AS1-L1-UIII, AS1-L2-UIII, AS2-L2-UIII, AS1-L2-UX, AS1-L1-UXI, AS1-L2-UXI	JS1-L2-UIII, JS2-L2-UIII JS1-L1-UXI, JS1-L2-UXI	Part I of UIII Test, Part I of Unit X Test, Part I of Unit XI Test	
Aa3	UIII-L3-I, UIII-L3-II, UIII-L3-III, UIII-L3-IV, UIII-L3-V-a, UIII-L3-V-b, UX-L1-I, UX-L1-II, UX-L1-III, UXI-L2-III, UXI-L2-V-c, UXI-L3-I, UXI-L3-II, UXI-L3-III-a	AS1-L3-UIII, AS1-L2-UX, AS2-L2-UXI, AS1-L3-UXI	JS1-L3-UIII, JS2-L3-UIII, JS3-L2-UXI, JS1-L3-UXI	Part II of Unit III Test, Part I of Unit X Test, Part II of Unit XI Test	
Bb1	UVI-L1-I, UVI-L1-II, UVI-L1-III, UVI-L2-I, UVI-L2-II, UVI-L2-III, UVI-L2-IV, UVI-L2-V, UVI-L3-III-a, UX-L2-II, UX-L2-III-a		JS1-L3-UVI, JS1-L2-UX	Unit VI Test, Parts I and II of Unit X Test	
Bb2	UXI-L2-IV, UXI-L2-V-d	AS1-L1-UII, AS3-L2-UXI	JS4-L2-UXI	Part II of Unit XI Test	
Bb3	UVI-L1-I, UVI-L1-II, UVI-L1-IV, UVI-L1-V, UVI-L1-VI, UVI-L2-I, UVI-L2-II, UVI-L2-III, UVI-L2-IV, UVI-L2-V, UVI-L3-I, UVI-L3-II, UVI-L3-III-a		JS1-L3-UVI	Unit Vi Test	

Competency	Instructional Objective		Job Sheet	Test Item	Notes
Dd6	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L2-I, UXII-L2-II, UXII-L2-III, UXII-L2-IV, UXII-L2-V,UXII-L2-VI-b	AS1-L2-UXII	JS2-L2-UXII	Unit XII Test	
Z1	UIV-L1-I, UIV-L1-II, UIV-L1-III, UV-L1-I, UV-L1-II, UV-L1-III-a, UV-L2-I, UV-L2-V, UV-L2-VI-a		JS1-L1-UV, JS1-L2-UV	Unit IV Test, Part I of Unit V Test	
Z2	UIV-L1-I, UIV-L1-II, UIV-L1-III, UV-L1-I, UV-L1-II, UV-L2-I, UV-L2-II, UV-L2-III, UV-L2-IV, UV-L2-VI-a, UXI-L2-II,UXI-L2-V-b	AS1-L3-UXI	JS1-L2-UV, JS2-L2-UXI	Unit IV Test, Part II of Unit V Test, Part I of Unit XI Test	

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT I: INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLE DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify basic characteristics of manual drive train and axle design. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with manual drive trains and transaxles (all competencies in the Manual Drive Train and Axles Module, Unit I Test).

II. Identify drive train components in rear-wheel and front-wheel-drive vehicles (all competencies in the Manual Drive Train and Axles Module, Unit I Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT I: INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLE DESIGN

CONTENTS OF THIS UNIT

A. Objective sheet

B. Unit introduction

C. References

D. Notes to the instructor

E. Lesson plans

  1. Lesson 1: MANUAL DRIVE TRAIN AND AXLE DESIGN

    a. Information outline

    b. Assignment sheets

      AS1-L1-UI: Manual Drive Train Designs

F. Unit test

G. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UI before taking the Unit I Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Fire Safety in the Auto Shop (AM-80-110), 1980.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT I: INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLE DESIGN

INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLES

A vehicle's drive train transfers power from the engine to the driving wheels. Depending upon what group of wheels is driven, the vehicle can be referred to as rear-wheel-drive, front-wheel-drive, or four-wheel-drive.

Throughout most of automotive history, vehicles have primarily used rear-wheel hotchkiss drive designs. In the hotchkiss design, the transmission (which contains the forward and reverse gears) receives power from the engine and then relays this power (by way of an open drive shaft) to the differential. The front wheels steer the car while the rear wheels move (or drive) it. The hotchkiss design is a relatively simple driving system.

In recent years, front-wheel-drive vehicles have become very popular. Because the weight of the entire drive train is over the driving wheels, front-wheel-drive vehicles offer superior wheel traction. The front-wheel-drive design also allows for greater space in the vehicle's interior because the drive train components do not push up into the floorboard.

Though the front-wheel-drive design offers many advantages, it is very complex. The transmission and differential are incorporated into one unit (called the transaxle). The front wheels must steer and accommodate bumps while still supplying smooth driving power. This design often requires special repair procedures.

Many trucks and even some cars use four-wheel-drive designs. Four-wheel-drive offers maximum traction by supplying turning power to all four wheels. A four-wheel-drive vehicle has a differential at both ends along with additional drive shafts. A unit called a transfer case is attached to the output of the transmission. The transfer case directs power to the rear and front differentials. Additional gears in the transfer case offer a lower gear range for heavy pulling. The additional gears also make it possible for the vehicle to operate in rear drive only. Special front-wheel hubs can be unlocked if the vehicle will be operating in rear-wheel-drive for extended periods of time. This feature saves wear on the front drive axles and related components by allowing them to stop turning while the vehicle is being driven.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT I: INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLE DESIGN

LESSON 1: MANUAL DRIVE TRAIN AND AXLE DESIGN

I. Terms and definitions

A. Axle--A hollow tube or solid shaft that supports or turns one or more wheels on a vehicle.

B. Axle housing--An enclosure for a vehicle's axles. The axle housing may contain bearings, lubrication, and gears.

C. Bellhousing--An enclosure for a vehicle's flywheel and clutch assembly or torque converter. The bellhousing bolts to the back of the engine block and provides a mounting for the transmission.

D. Casting--An object made by pouring molten metal into a mold.

E. Crankshaft--An iron or steel shaft that runs through the lower portion of a vehicle's engine. The crankshaft has offset portions that form throws to which the connecting rods attach. The crankshaft is the main source of power takeoff on the engine.

F. Dead axle--An axle that supports a vehicle's wheels (or wheel) on bearings but provides no turning power.

G. Differential--A device that drives a vehicle's back or front wheels while allowing them to turn at different speeds.

H. Drive shaft--A solid shaft or hollow tube that relays turning power either to the vehicle's differential or directly to the wheels. To allow for differential or wheel movement, the drive shaft usually has flexible joints at each end.

I. Drive train--A device that delivers power from a vehicle's engine to its wheels.

J. Friction disc (clutch disc)--A flat steel disc with a facing of friction material. The friction disc transfers turning power when pressed between two steel plates.

K. Gear--A metal disc into which teeth have been cut or molded. When two gears mesh, one causes the other to turn, thus transferring power.

L. Halfshaft--A shaft that drives only one of the two front wheels on a front-wheel-drive vehicle. The halfshaft contains a flexible joint, which permits wheel movement.

M. Hotchkiss drive--The most common means of transferring power from the transmission to the differential on rear-wheel-drive vehicles. The hotchkiss drive uses an open drive shaft.

N. Independent suspension--A type of wheel suspension which allows an individual wheel to bounce without affecting the other wheel on the same axle.

O. Live axle--An axle that supplies turning power to a wheel or wheels, though it may or may not support the wheel.

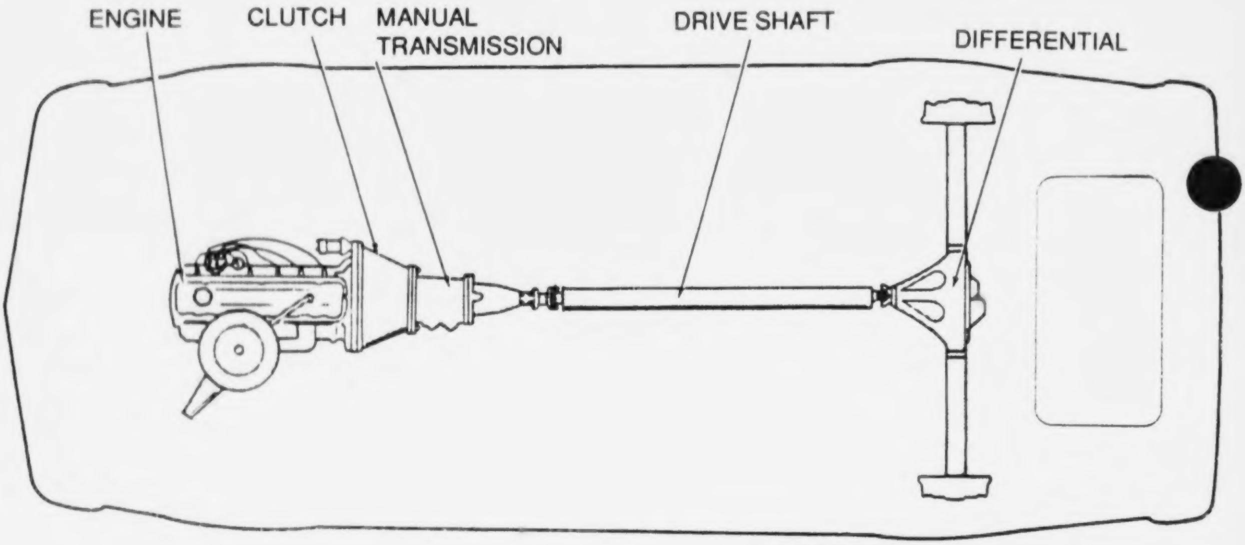
P. MacPherson strut--A telescopic device containing both a spring and a shock absorber. MacPherson struts are used on the front suspensions of some vehicles.

Q. Transaxle--A unit that contains both the transmission and the differential. Transaxles are commonly found on front-wheel-drive vehicles.

R. Transmission--A unit that transfers power from a vehicle's engine to its driving wheels.

S. Transverse engine mounting--A type of engine mounting that allows a vehicle's crankshaft to rotate in line with the drive axles and wheels. Transverse engine mounting is common in front-wheel-drive vehicles.

II. Components of the drive train in rear-wheel and front-wheel-drive vehicles



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Crouse/Anglin AUTOMOTIVE MECHANICS.
9th ed. New York: McGraw-Hill Book Company, 1985.

A. An automotive drive train consists of the transmission, clutch assembly, drive shaft, and differential.

1. The transmission contains gears, which provide the vehicle with either three, four or sometimes five forward speeds. The transmission also contains a neutral position and the reverse gears. The highest ratio forward gear (or high gear) is not really a gear at all but rather a direct drive used for cruising speeds.

(NOTE: Some cars have an even higher ratio gear called "overdrive." When a vehicle is in overdrive, the output shaft of the transmission actually turns faster than the engine crankshaft. Overdrive can save fuel at highway cruising speeds.)

2. The clutch assembly allows the driver to disconnect the driving power from the transmission and the rest of the drive train. The driver can therefore select a gear without stalling the engine or damaging the transmission. The clutch assembly also allows the driver to stop the car without shifting to neutral or stopping the engine.

    a. The clutch is a disc, which is faced on both sides with friction material and splined to the transmission input shaft.

    b. When compressed between the engine flywheel and another steel plate, the clutch (a disc) begins to grip and turn in unison with the engine flywheel. Turning power is thus transferred to the transmission.

    c. When the vehicle accelerates from a stop, the clutch is allowed to slip somewhat. This slippage provides a smoother engagement and keeps the engine from stalling.

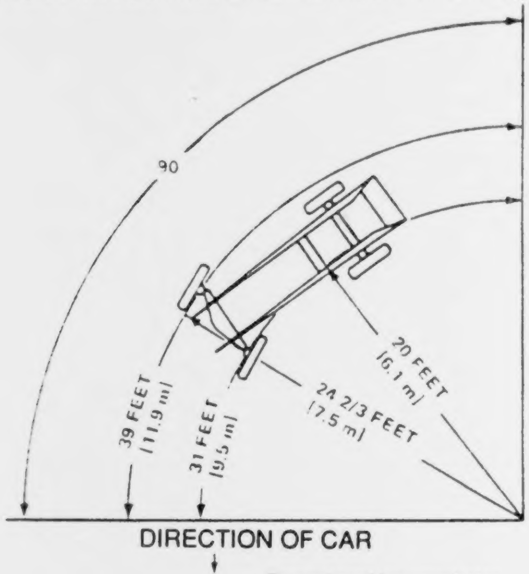
3. The drive shaft is a long hollow tube that relays turning power from the transmission to the differential. The drive shaft is balanced so that it spins without vibration. Since the rear wheels must move up and down with the rest of the car to accommodate bumps, the drive shaft must have flexible joints at both ends.

4. The differential serves three main functions in the drive train.

    a. First the differential changes the axis of rotation from the drive shaft (which runs lengthwise in the car) to the rear axle (which runs across the car).

    b. Secondly the differential transfers power from the drive shaft to the rear axle in a lower ratio; the power is then transferred to the wheels. In most vehicles, the drive shaft will spin about three times for each revolution of the wheels.

c. Finally, the differential must continue to supply turning power to the rear wheels even when the car is in a turn. During a turn, the vehicle's outside wheels must turn faster since they travel farther.



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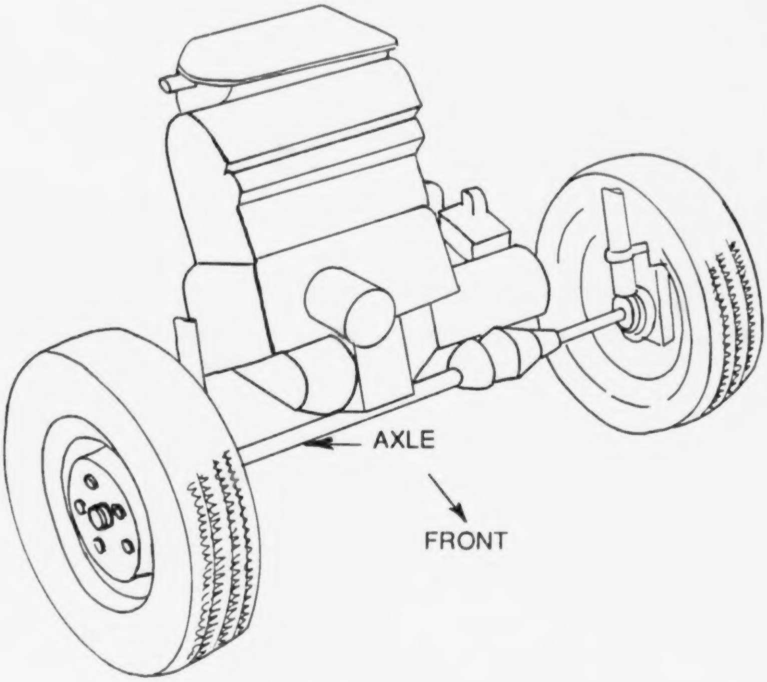
9th ed. New York: McGraw-Hill Book Company, 1985.

B. Drive trains in front-wheel-drive vehicles differ from those in rear-wheel-drive vehicles in the following ways.

1. In most front-wheel-drive vehicles, the engine is mounted transversely (i.e. the front of the engine points toward the right front fender). Transverse engine mounting allows the crankshaft to run in line with the front axle and wheels. The entire drive train is contained under the vehicle's hood, thus, saving much space.

   (NOTE: Early model, front-wheel-drive Oldsmobile Toronados and Cadillac Eldorados use conventional engine mounting.)

2. Front-wheel-drive vehicles use a transaxle assembly that combines the transmission and differential. The transaxle also houses the flywheel and clutch assembly, thus eliminating the bellhousing.



3. In front-wheel-drive vehicles, the transaxle assembly is bolted directly to the engine. The transaxle transfers power from the engine by means of a chain; therefore, a halfshaft is substituted for a conventional drive shaft.

   a. Halfshafts exit the transaxle's differential. Halfshafts relay turning power to each front wheel.

   b. Each halfshaft assembly contains flexible joints, which accommodate bumps by allowing the front wheel to move up and down with the rest of the vehicle.

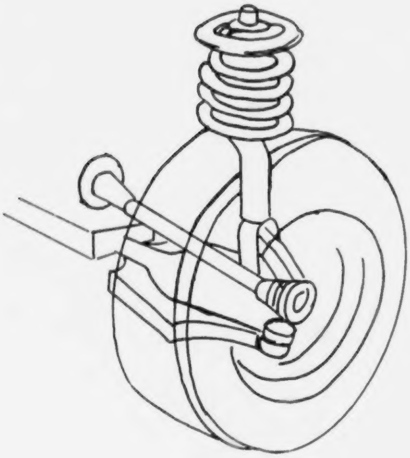
   c. Halfshaft joints must also allow the front wheels to steer while supplying smooth turning power.

4. Transverse engine mounting in front-wheel-drive vehicles does not allow sufficient space for a conventional long and short-arm independent front suspension. Most front-wheel-drive vehicles, therefore, use a MacPherson strut suspension system.

   a. The MacPherson strut is a telescopic device that contains a coil spring as well as a shock absorber.

   b. The spindle, bearing, and hub assemblies are mounted directly on the strut.

   c. MacPherson struts eliminate the need for an upper control arm. The struts also provide additional space for the engine and transaxle assemblies.



MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN DESIGNS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Explain the function of an automobile drive train.

2. List the major components of an automobile drive train.

3. Define the terms below.

   a. Differential

   b. Bellhousing

   c. Drive shaft

   d. Halfshaft

e. Transaxle

4. What important advantages does overdrive offer?

5. List the three main functions of the differential.

6. Explain why a small amount of clutch slippage during vehicle takeoff is necessary.

7. Explain what happens if clutch slippage becomes excessive.

8. Explain why it is important for the differential to slip (that is to allow the outside wheels to turn faster than the inside) when the vehicle turns.

MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN DESIGNS

(ANSWER SHEET)

1. The drive train transfers power from the vehicle's engine to its wheels.

2. Clutch, transmission, drive shaft (halfshaft), differential, axles, tires, and wheels

3. a. A unit that drives both wheels while allowing them to turn at different speeds
   b. An enclosure for the flywheel and clutch assembly or torque converter
   c. A shaft or tube that relays turning power either to the differential or directly to the wheels
   d. A shaft that drives only one of the two front wheels on a front-wheel-drive vehicle
   e. A unit that contains both the transmission and the differential

4. Overdrive reduces engine rpm and saves fuel.

5. The differential (1) transfers power from the drive shaft to the axles; (2) allows wheels to turn at different speeds during cornering; (3) changes the direction of the power flow from the transmission.

6. A small amount of clutch slippage during vehicle takeoff allows for smooth engagement and keeps the engine from stalling.

7. If clutch slippage becomes excessive, the clutch disc will prematurely fail. If a damaged clutch disc is not repaired, it will destroy the clutch flywheel and pressure plate.

8. Differential slippage ensures that the rear tires get adequate traction. Differential slippage also relieves stress from internal differential components.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT I: INTRODUCTION TO MANUAL DRIVE TRAIN AND AXLE DESIGN

UNIT I TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. A unit that drives a vehicle's back or front wheels while allowing them to turn at different speeds.

____ 2. An enclosure for the flywheel and clutch assembly or torque converter.

____ 3. An axle that may or may not support a wheel yet supplies it with turning power.

____ 4. A drive shaft that drives only one of the front wheels on front-wheel-drive vehicles.

____ 5. A hollow tube or solid shaft that supports or turns one or more wheels on a vehicle.

____ 6. An object made by pouring molten metal into a mold.

a. Axle

b. Bellhousing

c. Casting

d. Differential

e. Drive train

ab. Halfshaft

ac. Live axle

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 7. The drive train transfers turning power produced by the engine to the driving wheels of the vehicle.

____ 8. The hotchkiss drive design eliminates the problem of drive train components pushing up into the vehicle's floorboard.

____ 9. The hotchkiss design is one of the more complex type of driving systems.

____ 10. Front-wheel-drive vehicles offer superior wheel traction.

____ 11. Front-wheel-drive transmission designs are less complex than rear-wheel-drive designs.

____ 12. Four-wheel-drive systems require that a differential be used at both ends of the vehicle.

____ 13. When a vehicle with manual transmission accelerates from a stop, the clutch is allowed to slip somewhat.

____ 14. In most rear-wheel-drive vehicles, the engine is mounted sideways.

____ 15. Front-wheel-drive vehicles use a transaxle assembly that combines the transmission and differential.

SECTION C. Select the best answer from the five choices listed.

____ 16. The differential changes the axis of rotation from the drive shaft to the

a. crankshaft.
b. engine.
c. clutch assembly.
d. rear axle.
e. wheel hubs.

____ 17. A gear that allows the output shaft of the transmission to turn faster than the engine crankshaft is called

a. neutral.
b. overdrive.
c. the double lock gear.
d. the idle gear.
e. torque converter.

____ 18. A clutch is a type of

a. plastic disc.
b. expanding disc.
c. friction disc.
d. flywheel disc.
e. gear disc.

____ 19. Since the rear wheels must move up and down with the rest of the vehicle, the drive shaft must be equipped with

a. flexible joints at both ends.
b. sturdy rubber bushings at both ends.
c. self-lubricating bearings at both ends.
d. high-tension springs at both ends.
e. none of the above.

____ 20. For each revolution of the wheels, the drive shaft will usually spin about

a. five times.
b. ten times.
c. fifteen times.
d. twenty times.
e. none of the above.

____ 21. When a vehicle is turning, the outside wheels travel

a. faster than the inside wheels.
b. slower than the inside wheels.
c. at the same rate as the inside wheels.
d. at a twenty-degree angle from the inside wheels.
e. at a ten-degree angle from the inside wheels.

____ 22. The transaxle incorporates the flywheel and clutch assembly and, therefore, eliminates the

a. axle.
b. differential.
c. bellhousing.
d. halfshaft.
e. wheel hubs.

____ 23. In front-wheel-drive vehicles, the transaxle assembly is directly bolted to the engine. The transaxle assembly transfers power from the engine by way of a chain; therefore, there is no need for

a. an axle.
b. a clutch assembly.
c. a MacPherson strut.
d. a halfshaft.
e. a drive shaft.

____ 24. MacPherson struts eliminate the need for

a. a clutch assembly.
b. a halfshaft.
c. a drive shaft.
d. gears.
e. an upper control arm.

____ 25. In transverse engine mounting, the engine is mounted

a. backwards.
b. upside-down.
c. in the rear of the car.
d. sideways.
e. at a 45-degree angle.

(NOTE: The student must obtain a minimum score of _____ on the Unit I Test in order to receive an evaluation for any competencies in the Manual Drive Train and Axles Module.)

ANSWERS TO UNIT I TEST

1. d
2. b
3. ac
4. ab
5. a
6. c
7. t
8. f
9. f
10. t
11. f
12. t
13. t
14. f
15. t
16. d
17. b
18. c
19. a
20. e
21. a
22. c
23. e
24. e
25. d

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION

UNIT OBJECTIVE

After completing this unit, the student will be able to identify components of a manual transmission and the principles by which they operate. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with manual transmission gear design and operation (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

II. Identify the types of gears used in a manual transmission (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

III. Identify the principles of gear operation and the various gear ratios (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

Lesson 2. I. Identify terms and definitions associated with manual transmission design and operation (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

II. Identify manual transmission components and their functions (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

III. Identify the operating principles of the three-speed manual transmission (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

IV. Identify the operating principles of the four-speed manual transmission (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

V. Identify the operating principles of the five-speed manual transmission (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

VI. Identify the operating principles of the synchronizer assembly (all competencies in the Manual Drive Train and Axles Module, Unit II Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION

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A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: MANUAL TRANSMISSION GEAR DESIGN AND OPERATION

    a. Information outline

    b. Assignment sheet

      AS1-L1-UII: Manual Drive Train Operation

  2. Lesson 2: MANUAL TRANSMISSION DESIGN AND OPERATION

    a. Information outline

    b. Assignment sheets

      AS1-L2-UII: Manual Drive Train Design

E. Unit test

F. Answers to unit test

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Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A Suggested approaches to teaching this unit

1 Students should do AS1-L1-UII and AS1-L2-UII before taking the Unit II Test

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION

LESSON 1: MANUAL TRANSMISSION GEAR DESIGN AND OPERATION

I. Terms and definitions

  A. Direct drive--A condition in which the input and output components of an automotive transmission link together and turn at the same speed.

  B. Gear ratio--The relationship between the number of rotations of the driving gear and driven gear. If the driving gear turns three times for each rotation of the driven gear, the gear ratio is 3 to 1.

  C. Helical gear--A gear with teeth that run at a spiraling angle to the axis shaft.

  D. Idler gear--A gear meshed between two other gears, allowing those gears to turn in the same direction.

  E. Overdrive--A condition in which the drive shaft turns faster than the engine crankshaft.

  F. Spur gear--A gear with teeth that run in line with the axis shaft.

  G. Thrust--A force that pushes in line with the axis of a shaft.

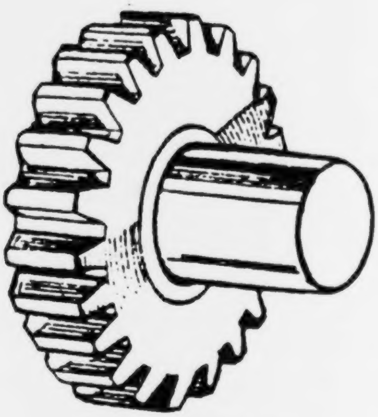
  H. Torque--A twisting or turning force applied to a shaft.

II. Types of gears

  A. Spur gear

    1. The spur gear is the simplest gear used in manual transmissions. The spur gear's teeth are cut in line with the axis shaft.

2. The spur gear is durable and relatively inexpensive to machine. Unfortunately it produces a whine during both high-speed and heavy torque operation. Use of the spur gear is, therefore, usually limited to the reverse gear.

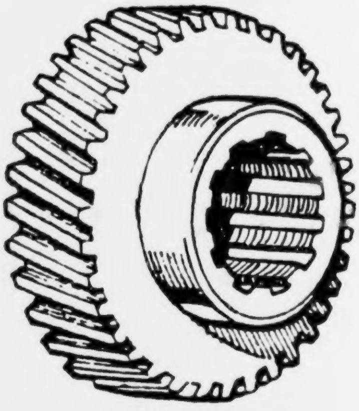


SPUR OR STRAIGHT

B. Helical gear

1. The teeth of the helical gear run at an angle to the axis; however, the teeth are actually machined in a spiral or helix. When torque is applied to helical gears, they thrust against one another. This side thrust is controlled with thrust bearings or thrust washers.

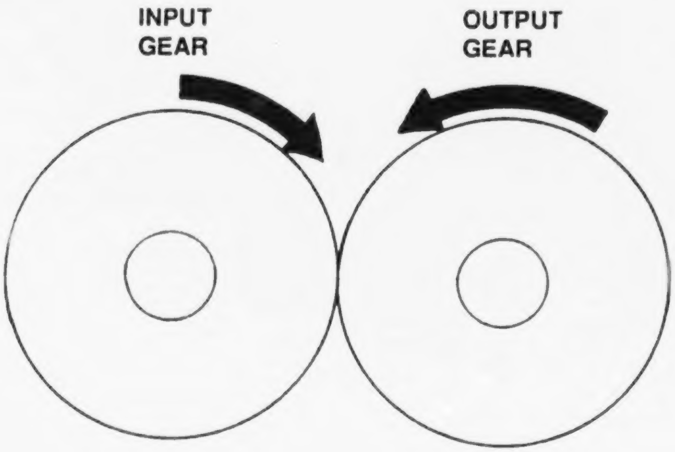
2. Though helical gears cost more to machine than spur gears, helical gears operate with little noise. Helical gears are also stronger because the thrust surface is spread across more than one tooth. The helical gear is the most common forward speed gear used in manual transmissions. In some manual transmissions, helical gears are even used as reverse gears.



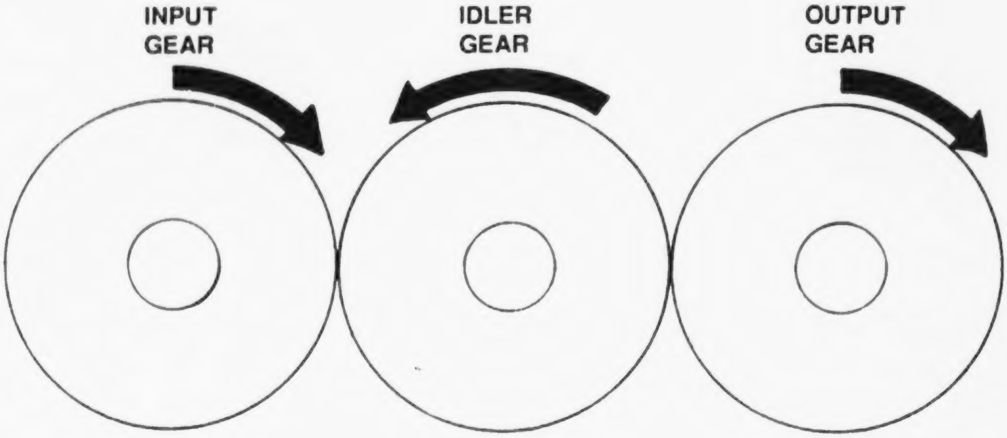
HELICAL

III. Gear operation and ratios

A. When two gears mesh, they turn in opposite directions.


INPUT GEAR
OUTPUT GEAR

B. When an idler gear is placed between two driving gears, the driving gears will turn in the same direction.

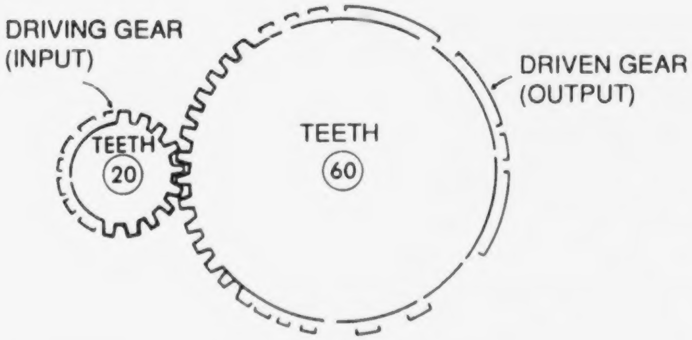

INPUT GEAR
IDLER GEAR
OUTPUT GEAR

C. Gear ratio is determined by dividing the number of teeth on the driven gear by the number of teeth on the driving gear.

1. 3 to 1 ratio

   a. If the number of teeth on the driven gear is 60 and the number of teeth on the driving gear is 20, the gear ratio can be calculated by dividing 60 by 20. The answer is 3. Therefore, the gear ratio is 3 to 1.

GEAR RATIOS

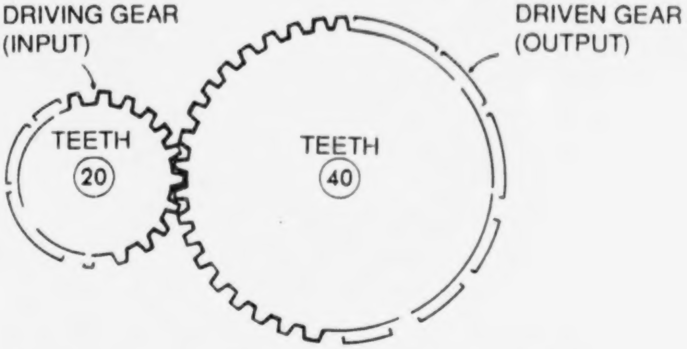

DRIVING GEAR (INPUT)
TEETH
20
TEETH
60
DRIVEN GEAR (OUTPUT)

TORQUE MULTIPLICATION
GEAR RATIO 3 TO 1
LOW GEAR
SPEED REDUCTION

   b. A gear ratio of 3 to 1 means that the driving gear will turn exactly 3 times before the driven gear completes one revolution. In a gear set with a 3 to 1 ratio, the output gear turns slower than a gear set with a smaller ratio (such as 2 to 1). The 3 to 1 ratio has more torque. A 3 to 1 ratio would, therefore, be referred to as a low gear. A vehicle uses low gears when accelerating or when extra pulling power is needed.

2. 2 to 1 ratio

   a. If the number of teeth on the driven gear is 40 and the number of teeth on the driving gear is 20, the gear ratio can be calculated by dividing 40 by 20. The answer is 2. Therefore, the gear ratio is 2 to 1.


DRIVING GEAR
(INPUT)
DRIVEN GEAR
(OUTPUT)
TEETH
20
TEETH
40

TORQUE MULTIPLICATION

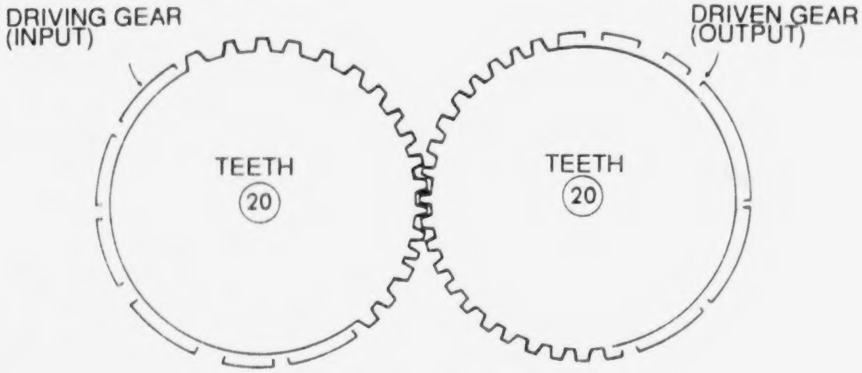
GEAR RATIO 2 TO 1
SECOND GEAR

SPEED REDUCTION

b. A gear set with a 2 to 1 gear ratio will still increase torque and vehicle speed, even though it is not as low a gear ratio as 3 to 1. The 2 to 1 ratio is suitable for second gear in manual transmissions.

3. 1 to 1 ratio

a. If the driven gear has 20 teeth and the driving gear has 20 teeth, the ratio can be calculated by dividing 20 by 20. The answer is 1. Therefore, the gear ratio is 1 to 1.

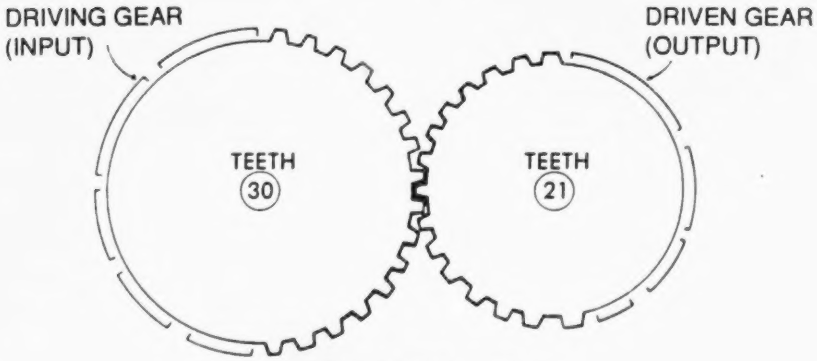

DRIVING GEAR
(INPUT)
DRIVEN GEAR
(OUTPUT)
TEETH
20
TEETH
20

GEAR RATIO 1 TO 1
HIGH GEAR
NO TORQUE MULTIPLICATION

b. The 1 to 1 ratio does not increase torque or vehicle speed. The same 1 to 1 ratio could more easily be achieved by directly linking the two shafts together for direct drive. Such a direct hook up occurs when a manual transmission is in high gear.

4. .7 to 1 ratio

a. Gear ratios are sometimes expressed with decimals. If the driven gear has 21 teeth and the driving gear has 30 teeth, the gear ratio can be calculated by dividing 21 by 30. The answer is .7. Therefore, the ratio is .7 to 1. Often the numbers do not divide evenly, so it is customary to express the ratio to two decimal places. When calculating gear ratios with numbers that do not divide evenly, remember to express the first number of the ratio to two decimal places and the last number always as 1.



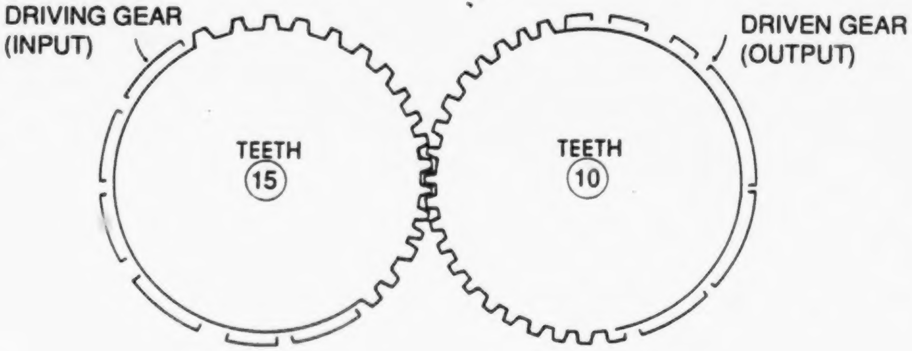
GEAR RATIO .7 TO 1
OVERDRIVE
TORQUE REDUCTION AND SPEED INCREASE

b. In a .7 to 1 gear ratio, the driven gear turns faster than the driving gear. Therefore, .7 is an example of an overdrive gear. A torque reduction will also be achieved in overdrive gears. Some transmissions have an overdrive gear for high speed operation.

MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN OPERATION

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.



1. What is the ratio of the gears shown in the above illustration? (Show calculations.)

2. If the driving gear in the above illustration is turning at 500 rpm, how fast is the driven gear turning? (Show calculations.)

3. In a 4 to 1 gear reduction ratio, how many teeth will the driven gear (output) have if the driving gear (input) has 12 teeth? (Show calculations.)

4. If the driving (input) gear in a 4 to 1 gear reduction ratio is turning at 160 rpm, at how many rpm is the driven (output) gear turning? (Show calculations.)

5. Explain why manufacturers prefer to use helical gears in manual transmissions.

6. Explain the difference between thrust and torque.

7. What is the function of an idler gear in a manual transmission?

MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN OPERATION

(ANSWER SHEET)

1. 1.5 to 1
2. 750 rpm
3. 44 teeth
4. 40 rpm
5. Helical gears make less noise. Helicals are also stronger because the thrust surface is spread across more than one tooth.
6. Thrust is a force that pushes in line with the axis of a shaft. Torque is a twisting or turning force applied to a shaft.
7. The idler gear allows the output gear to turn in the same direction as the input gear.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION

LESSON 2: MANUAL TRANSMISSION DESIGN AND OPERATION

I. Terms and definitions

   A. Ball bearings--An inner and outer steel race separated by hardened steel balls. Ball bearings reduce friction.

   B. Bushing--A friction-reducing sleeve made of a soft metal such as brass or bronze.

   C. Counter gear (cluster gear)--A one-piece group of gears cut into a long shaft. In a transmission, the counter gear connects the input shaft gear to the output or main shaft gears.

   D. Detent--A spring-loaded block or ball. The detent snaps into a groove or notch in an object and holds the object in place.

   E. Extension housing--A hollow case that bolts to the main transmission case and covers the output or main shaft.

   F. Main shaft--The shaft that exits the transmission at the rear. The main shaft is turned either by gears or the input shaft.

   G. Needle bearings--Small cylindrical steel rollers made of hardened steel. Needle bearings reduce friction between turning parts.

   H. Neutral--A condition in which there is no coupling between the transmission input shaft and output or main shaft.

   I. Output shaft--(see main shaft)

   J. Race--An inner or outer steel ring on a bearing. The race provides a contact surface for hardened steel balls or rollers.

   K. Roller bearing--A series of hardened steel rollers having either a straight cylindrical or tapered cylindrical shape.

   L. Shift fork (yoke)--A device which straddles the groove of a gear or sleeve. The shift gear allows a gear or sleeve to move back and forth, even if the gear or sleeve is spinning.

   M. Shim--A precision, washer-like part, which reduces or eliminates lash and end play between movable parts.

   N. Sliding gear--A transmission gear that can be slid axially to engage or disengage another gear.

   O. Snap ring--A split ring that can be snapped into a groove to retain gears, bearings, or other parts on a shaft.

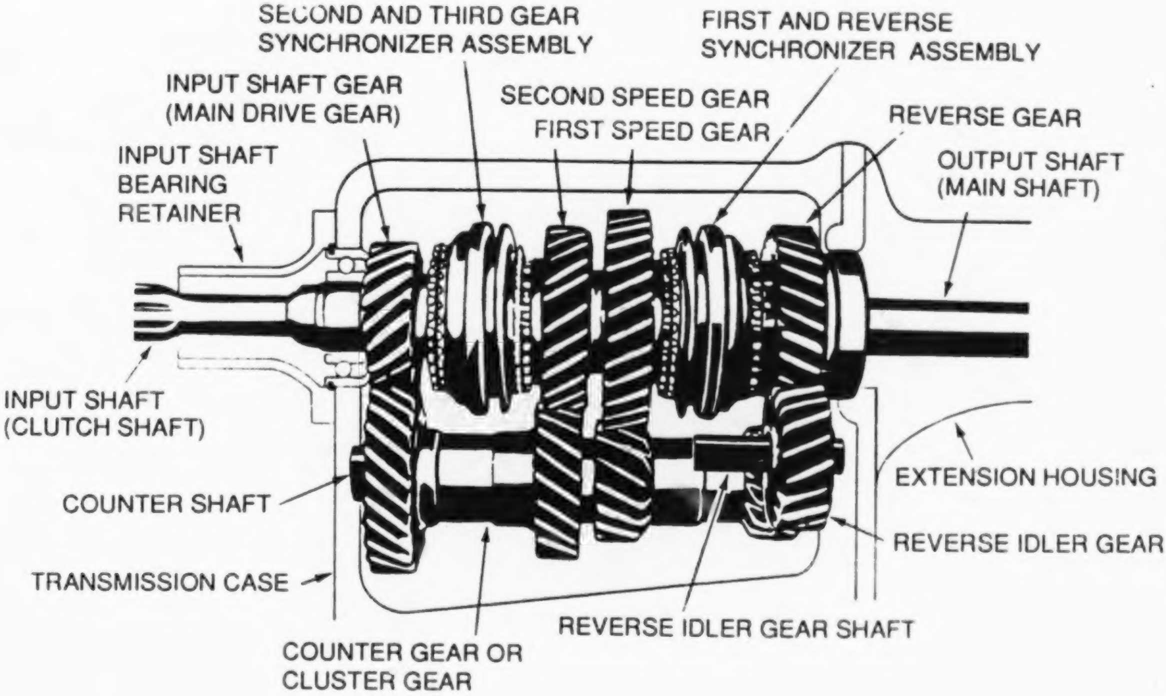
P. Spline--A groove or series of grooves cut into a shaft or other transmission component. A similarly grooved component can be slid onto the spline to form a mechanical connection.

Q. Synchromesh transmission--A transmission containing gears with turning speeds that are synchronized before the gears mesh with one another. This presynchronization prevents grinding or clashing of gear teeth.

R. Synchronizer ring--A transmission component made of a soft metal such as brass. The synchronizer ring is designed to grip the cone surface of a transmission gear in order to synchronize turning speeds prior to engagement.

S. Thrust washer--A washer or shim placed between two parts to limit thrust movement.

PARTS OF THE TRANSMISSION

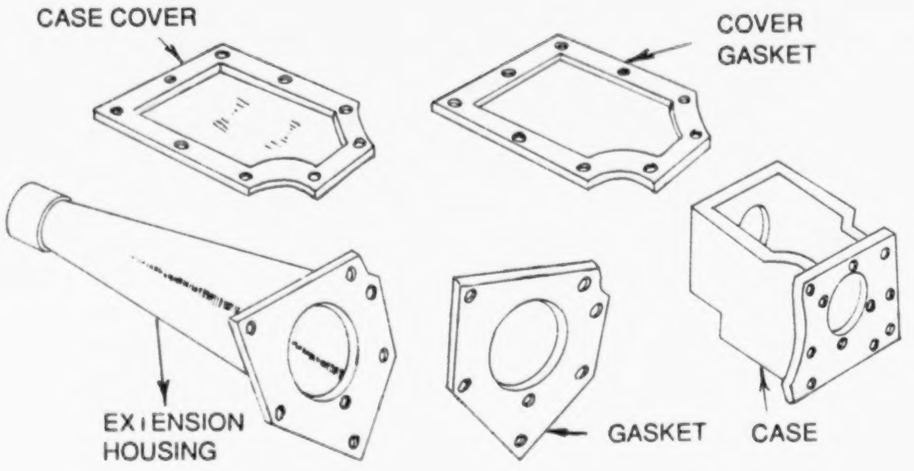

SECOND AND THIRD GEAR SYNCHRONIZER ASSEMBLY
FIRST AND REVERSE SYNCHRONIZER ASSEMBLY
INPUT SHAFT GEAR (MAIN DRIVE GEAR)
SECOND SPEED GEAR
FIRST SPEED GEAR
REVERSE GEAR
INPUT SHAFT BEARING RETAINER
OUTPUT SHAFT (MAIN SHAFT)
INPUT SHAFT (CLUTCH SHAFT)
EXTENSION HOUSING
COUNTER SHAFT
REVERSE IDLER GEAR
TRANSMISSION CASE
REVERSE IDLER GEAR SHAFT
COUNTER GEAR OR CLUSTER GEAR

II. Manual transmission components and their functions

A. Case and extension housing

1. The case and extension housing are cast of either aluminum or cast iron. Certain areas of the case and extension housing are designed to mate. These areas are milled smooth for an exact fit. The part of the case that mates with the bellhousing is also milled smooth.

2. Precise holes are drilled in the case for bearings, shafts, and mounting bolts. Gaskets form a seal between the main case and extension housing, and also between the case and inspection cover plate.

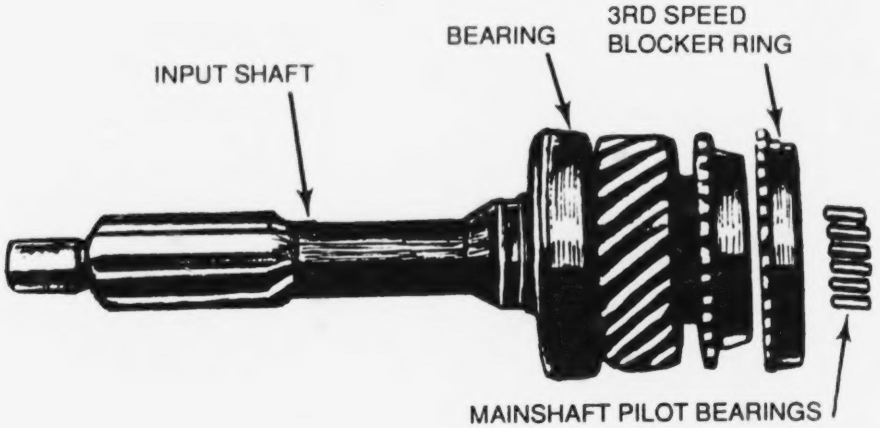


B. Input shaft

1. The input shaft has splines on one end. The clutch disc slides on these splines. This connection allows the input shaft to receive turning power and transfer it to the transmission.

2. A large ball bearing supports the input shaft in the transmission case. The clutch-end of the shaft is supported and centered by a pilot bushing or bearing. The pilot bearing is pressed into a machined cavity in the engine crankshaft.

3. Inside the transmission case, the input shaft has a helical gear, which transfers turning power to the other gears. The input shaft also has external engagement teeth and a smooth cone surface that lock with the main shaft for direct drive (high gear).

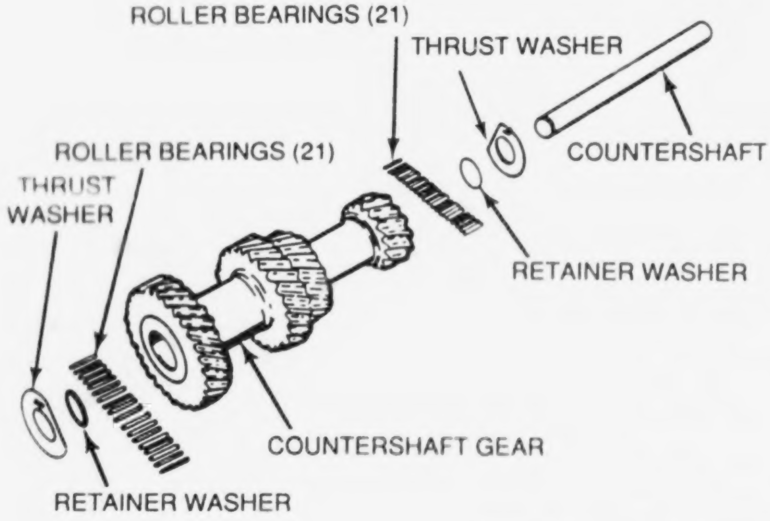


INPUT SHAFT
BEARING
3RD SPEED BLOCKER RING
MAINSHAFT PILOT BEARINGS

Courtesy of General Motors Corporation

C. Counter gear (cluster gear)

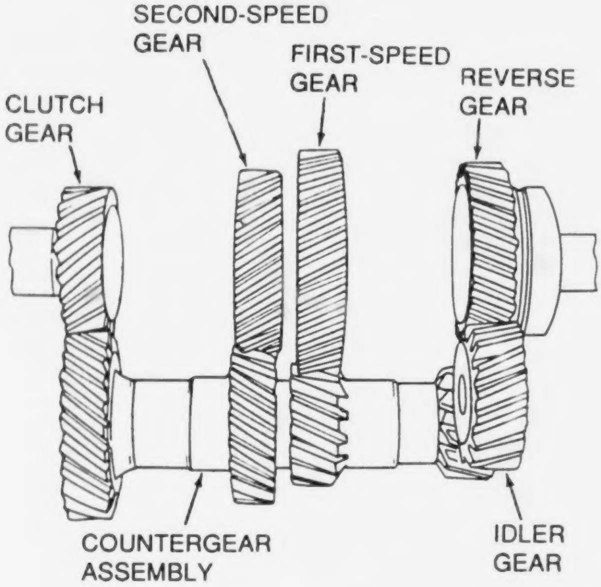
1 The counter gear is actually a series of gears machined into one long shaft, which runs the full length of the transmission case. The counter gear spins on rows of needle bearings and a steel shaft. Thrusting forces are controlled by thrust washers located at each end of the shaft.



ROLLER BEARINGS (21)
THRUST WASHER
COUNTERSHAFT
ROLLER BEARINGS (21)
THRUST WASHER
RETAINER WASHER
COUNTERSHAFT GEAR
RETAINER WASHER

Courtesy of Ford Motor Company

2. The counter gear meshes at all times with the input shaft gear and the other forward gears. Any time the clutch is engaged, it is relaying power to the input shaft. The input shaft gear turns the counter gear. The counter gear will then turn all other forward gears.



Reproduced by permission.
Crouse/Anglin AUTOMOTIVE MECHANICS.
9th ed. NewYork: McGraw-Hill Book Company, 1985.

D. Main (output) shaft and gear assembly

1. The main shaft is the output shaft of the transmission. The main shaft exits the rear of the transmission and splines with the drive shaft.

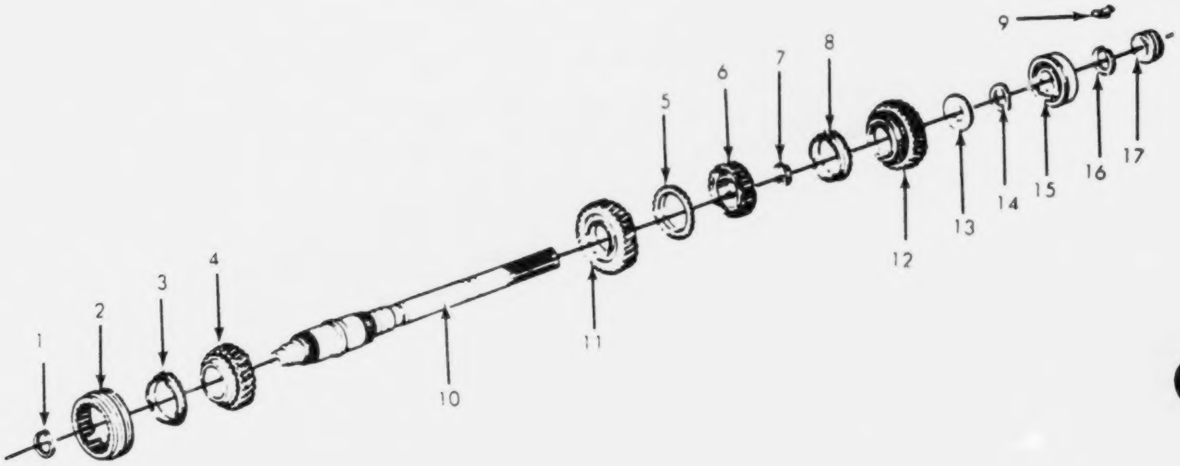
2. The main shaft is supported and centered at the front end by roller bearings. The middle of the main shaft is supported by a large ball bearing either at the rear of the case or the front of the extension housing. A bushing in the end of the extension housing supports the end of the main shaft when the drive shaft yoke is inserted. Bushings on the inside of the main shaft gears allow them to spin freely on the shaft's smooth journals.

3. Synchronizer hubs with internal splines are positioned on the main shaft between the gears. These hubs must turn with the main shaft. The synchronizer hubs also have external splines on which the synchronizer sleeves slide. Spring-loaded detent keys retain the sleeve in a forward, center, or rear position.

4. The gears have a set of external synchronizer teeth, which can interlock with the internal splines of the synchronizer sleeves. A gear is selected by sliding the synchronizer sleeve either forward or backward and thereby engaging the gear to the main shaft.

5. Synchronized shifting transmissions have brass synchronizer rings (blocker rings) between the sliding synchronizer sleeves and gears. These rings grip a smooth cone surface on the gear just prior to engagement, causing the gear and sleeve to turn at the same speed, thus providing grind-free shifting.

(NOTE: A speedometer drive gear is attached to the rear of the main shaft.)



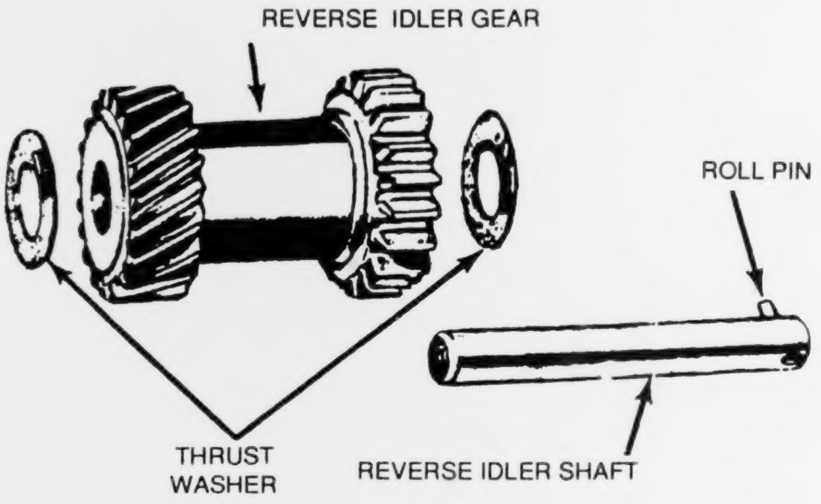
1. 4-3 SYNCHRONIZER SNAP RING
2. 4-3 SYNCHRONIZER
3. 3RD SPEED BLOCKER RING
4. 3RD GEAR
5. 2ND SPEED BLOCKER RING
6. 1-2 SYNCHRONIZER AND REVERSE GEAR
7. 1-2 SYNCHRONIZER SNAP RING
8. 1ST SPEED BLOCKER RING
9. RETAINING CLIP
10. MAIN SHAFT
11. 2ND GEAR
12. 1ST GEAR
13. REVERSE GEAR THRUST WASHER
14. WAVE WASHER
15. REAR BEARING
16. REAR BEARING SNAP RING
17. SPEEDOMETER DRIVE GEAR

Courtesy of General Motors Corporation

E. Reverse idler gear and shaft

1. When in reverse, the vehicle's main (output) shaft must rotate in a direction opposite to the direction it rotates when moving the vehicle forward. The reverse idler gear makes this change in rotation possible.

2. The reverse idler gear spins on its own bushing and shaft, which is usually press-fit into the transmission case. Either thrust washers, or an "E ring," or both control thrust movements of the reverse idler gear.

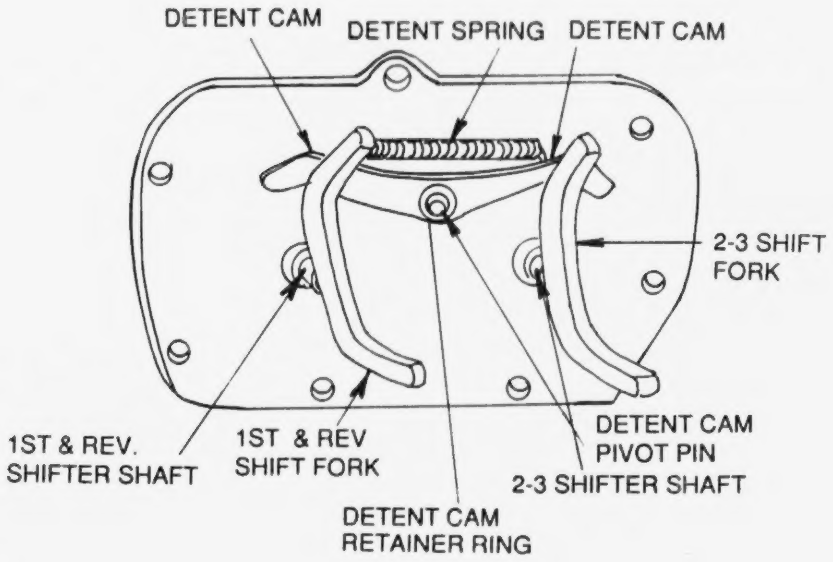


Courtesy of Ford Motor Company

F. Shift fork and detents

1. Shift forks straddle grooves in the synchronizer sleeves to enable the sleeves to slid into or out of engagement.

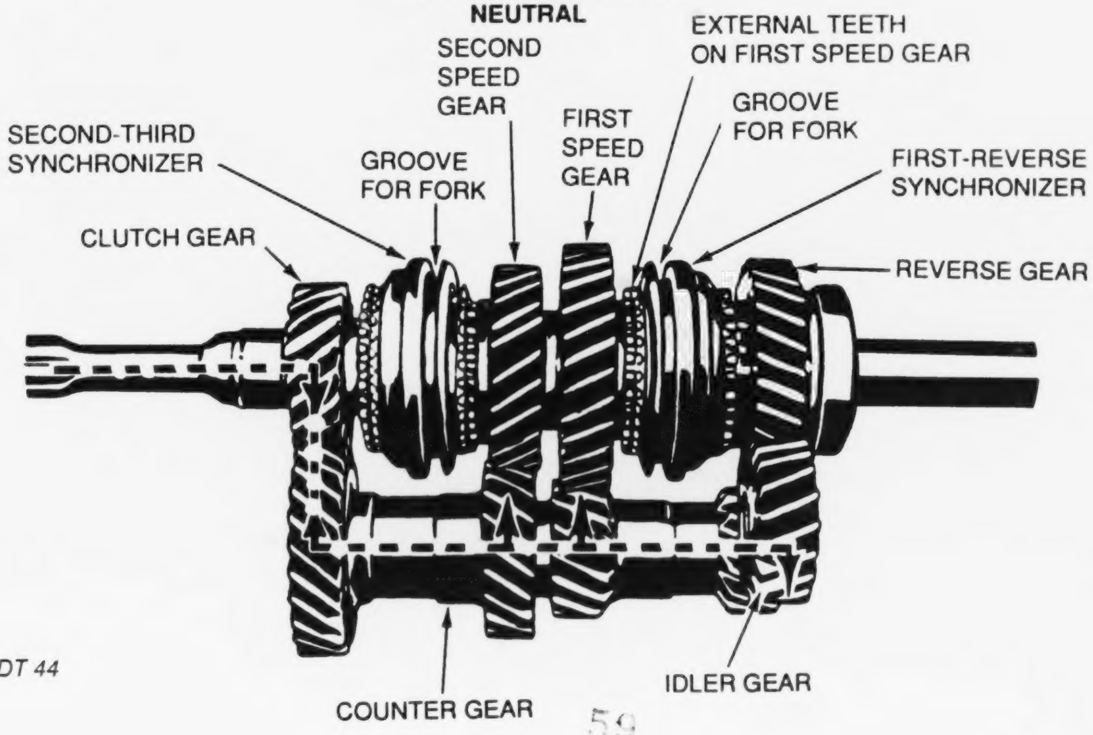
2. A system of detents retains the forks in the desired position. Most transmissions use a detent-design shift mechanism to prevent the driver from selecting two different gears at the same time.


DETENT CAM
DETENT SPRING
DETENT CAM
2-3 SHIFT FORK
DETENT CAM PIVOT PIN
2-3 SHIFTER SHAFT
1ST & REV. SHIFTER SHAFT
1ST & REV SHIFT FORK
DETENT CAM RETAINER RING

III. Manual transmission operation (three-speed)

A. Operation of the transmission while in neutral

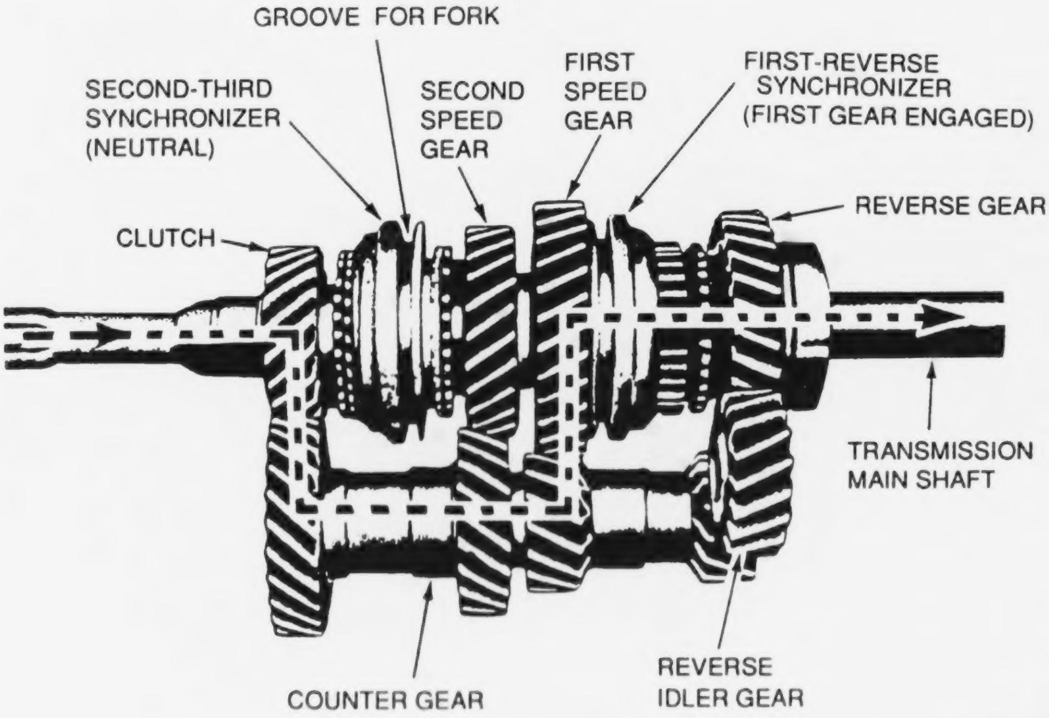
TRANSMISSION OPERATION
NEUTRAL


SECOND SPEED GEAR
EXTERNAL TEETH ON FIRST SPEED GEAR
GROOVE FOR FORK
FIRST SPEED GEAR
SECOND-THIRD SYNCHRONIZER
GROOVE FOR FORK
FIRST-REVERSE SYNCHRONIZER
CLUTCH GEAR
REVERSE GEAR
IDLER GEAR
COUNTER GEAR

1. The input shaft gear and counter gear are in constant mesh. They turn anytime that the clutch is engaged.
2. The counter gears turn the forward gears (and remain in constant mesh with the forward gears).
3. Since no gear has yet been coupled with the main shaft, no power is transferred. The gears spin freely at different speeds.

B. Operation of the transmission while in first gear

TRANSMISSION OPERATION
FIRST GEAR

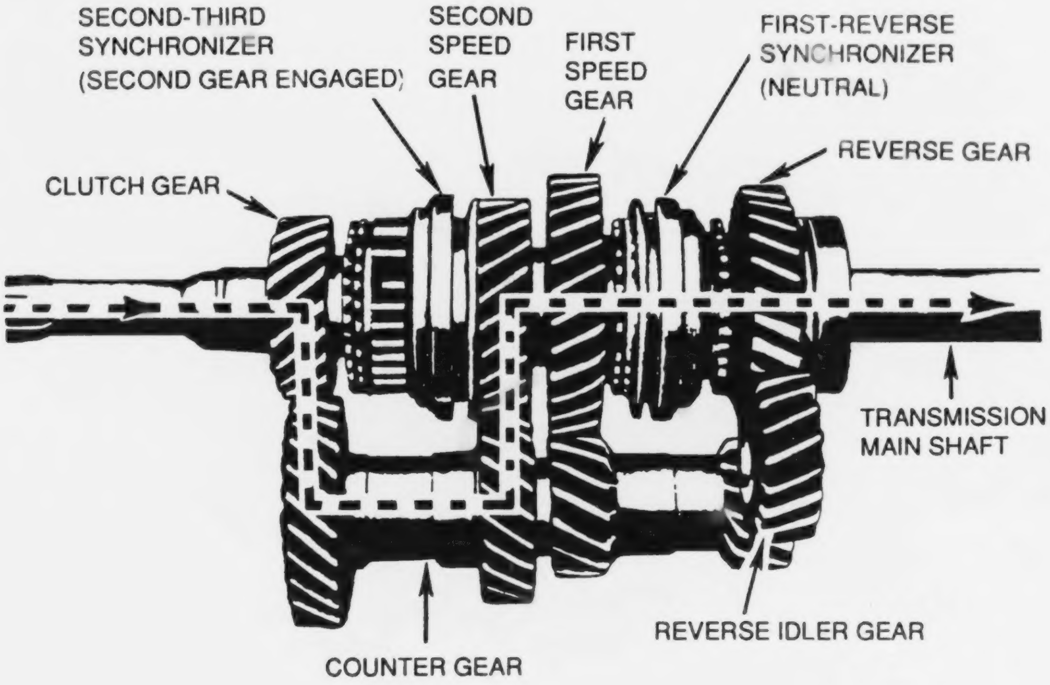

GROOVE FOR FORK
SECOND-THIRD SYNCHRONIZER (NEUTRAL)
SECOND SPEED GEAR
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (FIRST GEAR ENGAGED)
REVERSE GEAR
CLUTCH
TRANSMISSION MAIN SHAFT
REVERSE IDLER GEAR
COUNTER GEAR

1. The first-reverse synchronizer sleeve is slid forward to engage the external synchronizer teeth on first gear.
2. First gear is locked to the main shaft through the synchronizer sleeve and hub, both of which are splined to the main shaft.
3. Power flows from the input shaft gear to the counter gear.
4. The counter gear turns first gear.
5. First gear is now coupled with the main shaft and, therefore, turns it.

6. The ratio of first gear is low. Therefore, first gear delivers less turning speed but greater torque.

C. Operation of the transmission while in second gear

**TRANSMISSION OPERATION
SECOND GEAR**


SECOND-THIRD SYNCHRONIZER (SECOND GEAR ENGAGED)
SECOND SPEED GEAR
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (NEUTRAL)
REVERSE GEAR
CLUTCH GEAR
TRANSMISSION MAIN SHAFT
REVERSE IDLER GEAR
COUNTER GEAR

1. The first-reverse synchronizer sleeve is slid to the middle (neutral) position. The second-third synchronizer sleeve is slid back to engage second gear.

2. Second gear is locked to the main shaft through the synchronizer sleeve and hub.

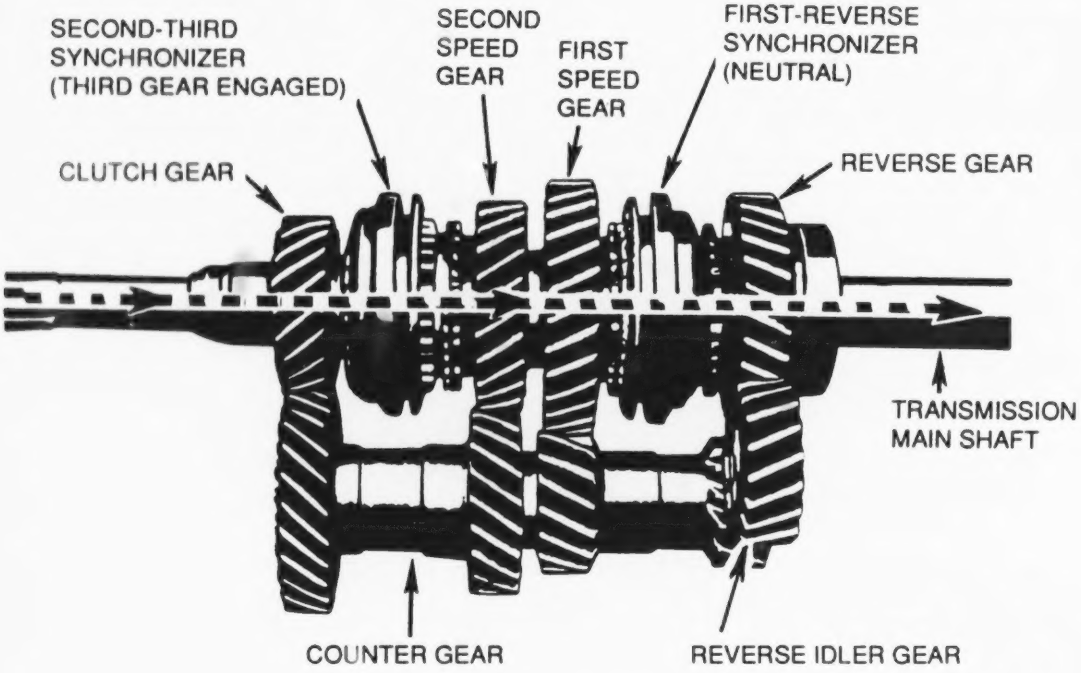
3. Power flows from the input shaft gear to the counter gear, which then turns second gear.

4. Second gear is now coupled with the main shaft and, therefore, turns it.

5. The ratio of second gear is higher than that of first gear. Therefore, second gear turns the main shaft with more speed and less torque than first gear.

D. Operation of the transmission while in third gear (direct drive)

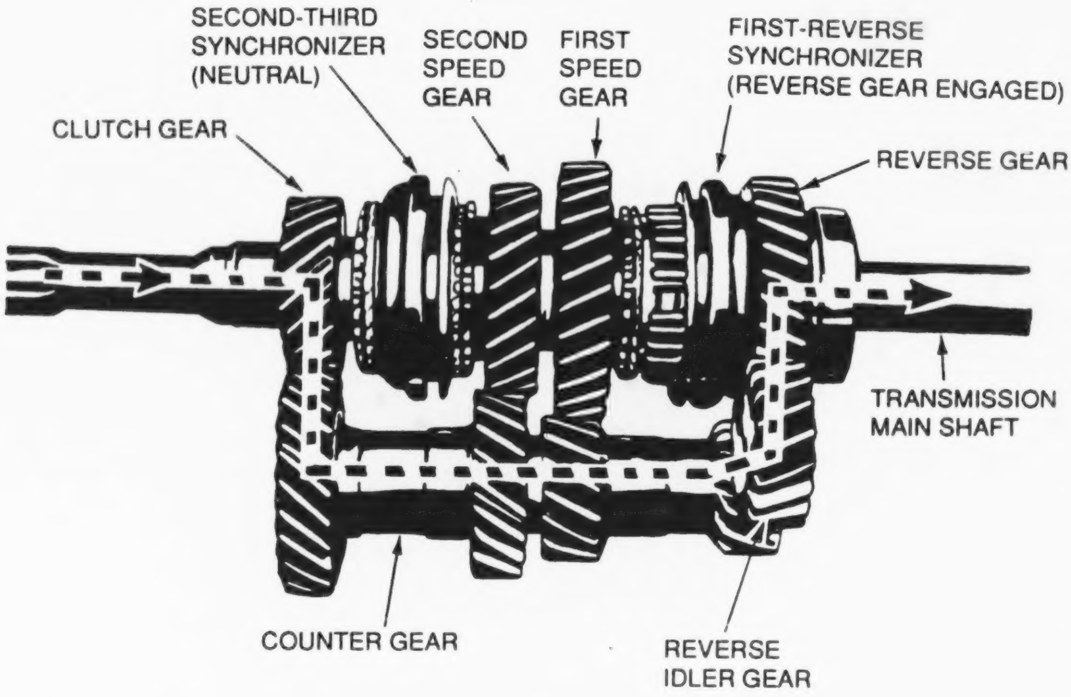
TRANSMISSION OPERATION
THIRD GEAR


SECOND-THIRD SYNCHRONIZER (THIRD GEAR ENGAGED)
SECOND SPEED GEAR
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (NEUTRAL)
CLUTCH GEAR
REVERSE GEAR
TRANSMISSION MAIN SHAFT
COUNTER GEAR
REVERSE IDLER GEAR

1. The second-third synchronizer sleeve is slid forward to engage the external synchronizer teeth on the input shaft.
2. The input shaft is locked to the main shaft.
3. Power flows directly from the input shaft to the main shaft in a 1 to 1 ratio. This ratio represents direct drive or third gear.
4. The other gears, while still being turned by the counter gear, are not coupled to the main shaft.

E. Operation of the transmission while in reverse

TRANSMISSION OPERATION
REVERSE


SECOND-THIRD SYNCHRONIZER (NEUTRAL)
SECOND SPEED GEAR
FIRST SPEED GEAR
FIRST-REVERSE SYNCHRONIZER (REVERSE GEAR ENGAGED)
CLUTCH GEAR
REVERSE GEAR
TRANSMISSION MAIN SHAFT
COUNTER GEAR
REVERSE IDLER GEAR

1. The second-third synchronizer sleeve returns to the middle (neutral) position.

2. The first-reverse synchronizer sleeve is slid back to engage the reverse gear.

3. Power flows from the input shaft gear to the counter gear.

4. The counter gear turns the reverse idler gear. The reverse idler gear then turns the reverse gear.

5. The reverse gear and main shaft now turn in opposite directions in a low ratio (less turning speed, greater turning torque).

IV. Manual transmission operation (four-speed)

A. The reverse gear of the three-speed transmission is replaced with first gear.

B. First gear of the three-speed transmission is replaced with second gear.

C. In the four-speed, the first-reverse synchronizer is changed to the first-second synchronizer sleeve.

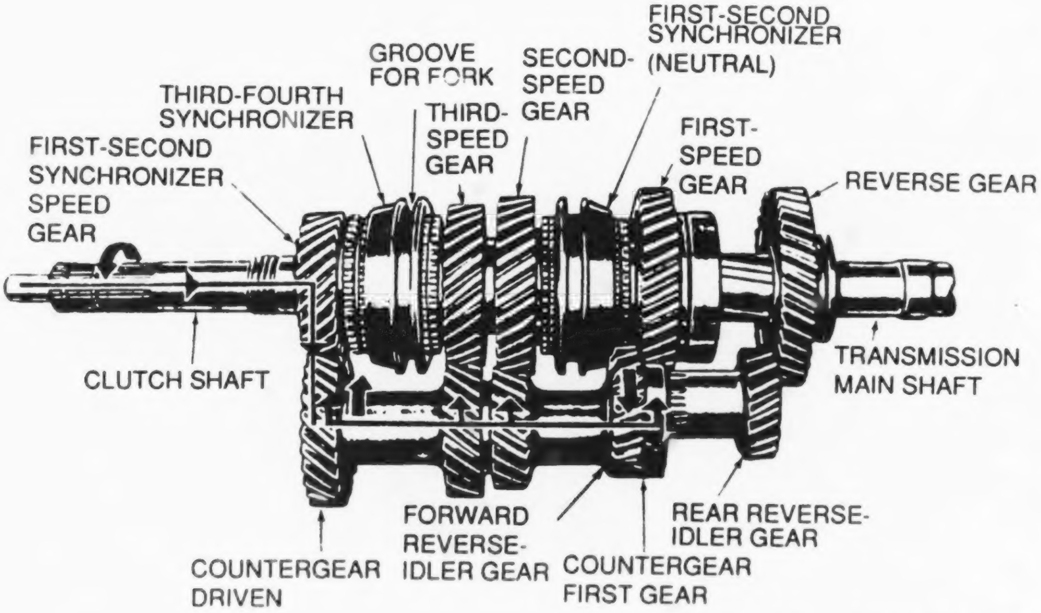
D. Second gear of a three-speed transmission is replaced with third gear in a four-speed.

E. In both three and four-speed transmissions, the input shaft and main shaft are directly coupled when the vehicle is in high gear. (In a four-speed transmission, fourth gear is, of course, high gear.)

F. The three-speed transmission uses a second-third synchronizer sleeve. The four-speed uses a third-fourth synchronizer sleeve.

G. In a four-speed transmission, the reverse gear is located in the extension housing. The reverse gear is slid into engagement with another shift fork and rod assembly.

H. All other operating principles of the four-speed transmission are the same as those for the three-speed transmission.


FIRST-SECOND SYNCHRONIZER SPEED GEAR
THIRD-FOURTH SYNCHRONIZER
GROOVE FOR FORK
THIRD-SPEED GEAR
SECOND-SPEED GEAR
FIRST-SECOND SYNCHRONIZER (NEUTRAL)
FIRST-SPEED GEAR
REVERSE GEAR
CLUTCH SHAFT
TRANSMISSION MAIN SHAFT
COUNTERGEAR DRIVEN
FORWARD REVERSE-IDLER GEAR
COUNTERGEAR FIRST GEAR
REAR REVERSE-IDLER GEAR

Courtesy of General Motors Corporation

V. Manual transmission operation (five-speed)

A. In a five-speed transmission, fifth gear is overdrive. (As was stated earlier, overdrive has a ratio of less than 1 to 1, which provides greater turning speed but less torque.)

B. Fifth gear is located in the extension housing with the reverse gear.

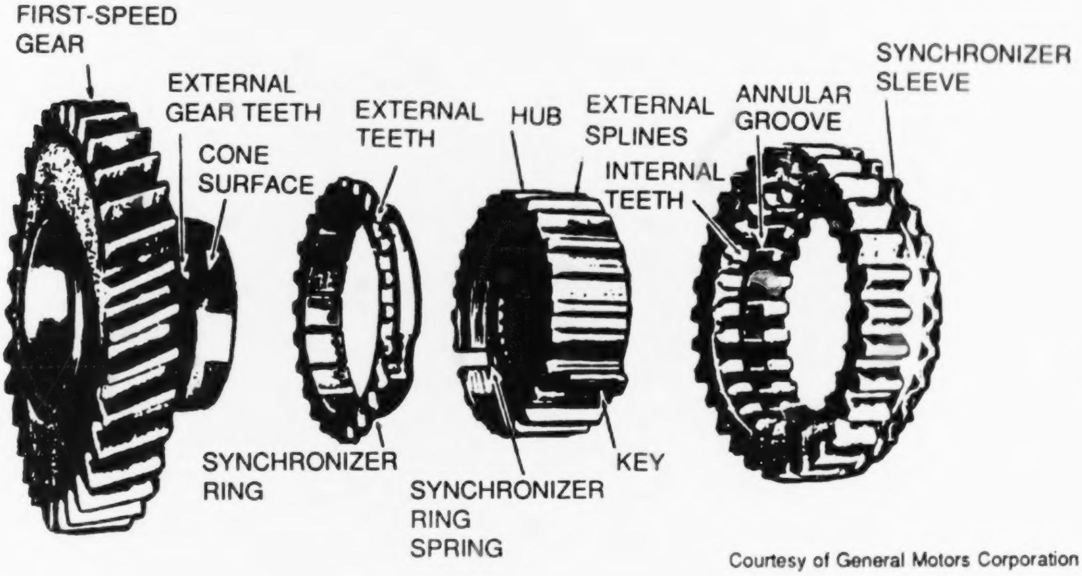
C. Shifting is accomplished with an additional synchronizer sleeve designed exclusively for fifth gear.

D. A fifth-reverse shift rail moves two shift forks: the fifth gear fork, and the reverse gear fork.

E. An additional synchronizer ring (blocker ring) is used for fifth gear.

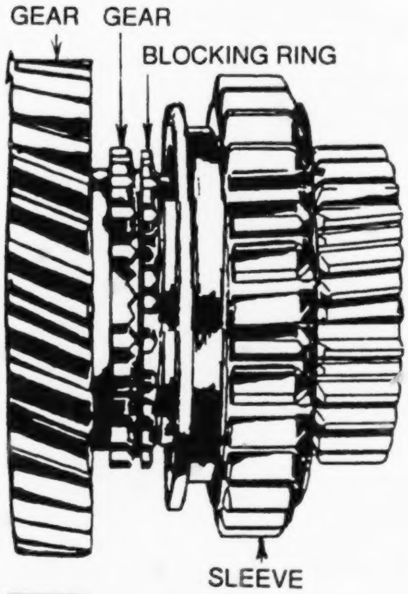
F. All other operating principles are the same as those for four-speed transmissions.

VI. The synchronizer assembly is a cluster of internally and externally cut gears that can be interlocked. There is usually a synchronizer assembly for each gear in the transmission. When the synchronizer is not interlocked, the individual gears turn at different speeds. When the synchronizer is interlocked, the assembly turns as a single unit. The purpose of the synchronizer assembly is to lock the transmission into different gear ratios.


FIRST-SPEED GEAR
EXTERNAL GEAR TEETH
CONE SURFACE
EXTERNAL TEETH
HUB
EXTERNAL SPLINES
INTERNAL TEETH
ANNULAR GROOVE
SYNCHRONIZER SLEEVE
SYNCHRONIZER RING
SYNCHRONIZER RING SPRING
KEY

Courtesy of General Motors Corporation

EXTERNAL SYNCHRONIZER RING TEETH (CLOSE-UP)



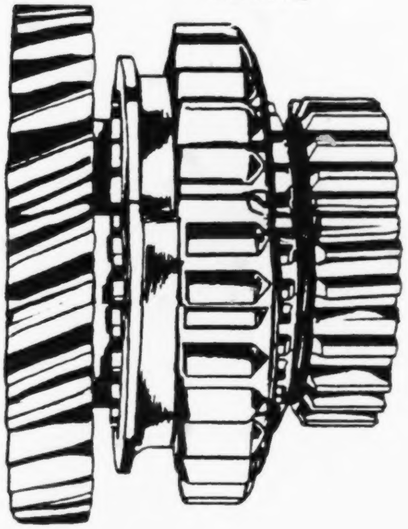
STEP ONE

Synchronizer sleeves contain an internal annular groove into which the detent keys snap under spring tension.

When the shift fork begins to slide the synchronizer sleeve towards a gear, the detent keys slide along, carried by the annular groove.

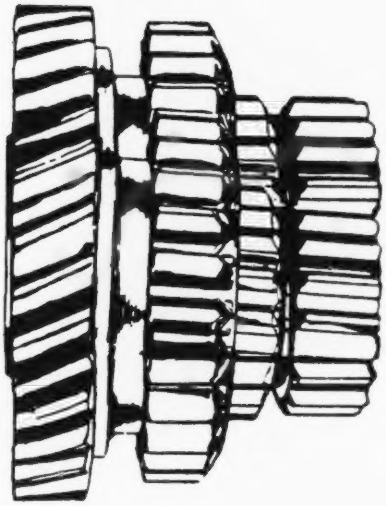
The detent keys run into the brass synchronizer ring, pressing it against the cone surface of the gear.

The detent keys fit into machined slots in the synchronizer ring, thus turning the ring with the hub and main shaft.



STEP TWO

More pressure is applied as the internal splines of the synchronizer sleeve run into the external teeth of the synchronizer ring, which are in temporary misalignment. Friction between the brass synchronizer ring and the cone surface of the gear accelerates the gear to the same speed.



STEP THREE

When the gear and the synchronizer ring, sleeve, and hub are turning in unison, tension on the ring is relieved. The pointed internal splines of the sleeve can then move the external teeth of the synchronizer ring into alignment.

With the synchronizer ring teeth now in alignment with the sleeve's internal splines, the sleeve can move further to engage the gear's external synchronizer teeth. This further movement of the sleeve compresses the detent keys against the spring, and the sleeve snaps into position. Due to the synchronized turning upon gear engagement, a clash-free shift is accomplished.

MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN DESIGN

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Explain the function of a blocking ring and synchronizer in a manual transmission.

2. Explain the difference between a bushing and a bearing.

3. List the three drive gears that could be engaged in a three-speed transmission if power is flowing through the transmission's cluster gear.

4. Explain the importance of thrust washers in a manual transmission.

5. Is a thrust washer a bearing or a bushing?

6. If a vehicle with a manual, three-speed transmission is in neutral while the clutch is engaged and the engine is running, which shafts and gears in the transmission are turning and which are stationary? (Write the names of the proper shafts and gears in the spaces below.)

   Turning shafts and gears:

   Stationary shafts and gears:

7. What gear is a manual, three-speed transmission in if the input shaft and output shaft are turning in the same direction and at the same speed?

MODULE: MANUAL DRIVE TRAIN AND AXLES

MANUAL DRIVE TRAIN DESIGN

(ANSWER SHEET)

1. The blocking rings and synchronizers work together to provide grind-free shifting. The rings grip a smooth cone surface on the gear just prior to engagement, causing the gear and sleeve to turn at the same speed.

2. A bushing reduces friction by providing a relatively soft contact surface for a nearby turning component. A bushing is a single component. A bearing reduces friction by separating the moving parts. The bearing consists of an outer race and an inner race with needle or roller bearings in between.

3. 2nd gear, 3rd gear, reverse

4. Thrust washers reduce friction between moving parts in the transmission and hold gears in place.

5. A bushing

6. Turning shafts and gears: input shaft, input gear, counter gear and shaft, reverse idler gear, 1st speed gear, 2nd speed gear, 3rd speed gear, reverse gear

   Stationary shafts and gears: output shaft

7. 3rd gear (or high gear)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT II: MANUAL TRANSMISSION COMPONENTS AND THEIR OPERATION

UNIT II TEST

SECTION A. **Match the terms below with their correct definitions.**

____ 1. A gear with teeth that run at a spiraling angle to the axis shaft.

____ 2. The relationship between the number of times the driving gear turns and the number of times the driven gear turns.

____ 3. A gear which meshes between two other gears and allows them to turn in the same direction.

____ 4. A gear with teeth that run in line with the axis shaft.

____ 5. A condition in which the input and output or main shaft are linked so that they can turn at the same speed.

____ 6. A force that pushes in line with the axis of a shaft.

____ 7. A twisting or turning force applied to a shaft or part.

a. Direct drive
b. Gear ratio
c. Helical gear
d. Idler gear
e. Overdrive
ab. Spur gear
ac. Thrust
ad. Torque

SECTION B. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 8. The spur gear is the simplest gear used in manual transmissions.

____ 9. Helical gears produce excessive noise while operating.

____ 10. Idler gears allow meshed gears to turn in different directions.

____ 11. A gear ratio of 3 to 1 means that the driving gear will turn exactly 3 times before the driven gear completes one turn.

____ 12. A 3 to 1 gear ratio creates greater torque than smaller gear ratios.

____ 13. In a manual transmission, a 3 to 1 gear ratio might be referred to as low gear.

____ 14. A transmission bushing is a friction-reducing sleeve made of steel or, in some cases, cast iron.

____ 15. In a manual transmission, the counter gear connects the input shaft gear to the output or main shaft gears.

____ 16. The main shaft is connected directly to the engine crankshaft.

____ 17. Synchromesh transmissions are inexpensive and easy to service, but often produce gear clatter and grind.

____ 18. The case and extension housing of a transmission are usually cast of a soft metal such as brass or bronze.

____ 19. The transmission input shaft is joined with the clutch disc.

____ 20. The clutch in the transmission is centered by a pilot bushing or bearing, which is pressed into a machined cavity in the engine crankshaft.

____ 21. In a three-speed transmission, the counter gear is a single gear found at either end of the transmission.

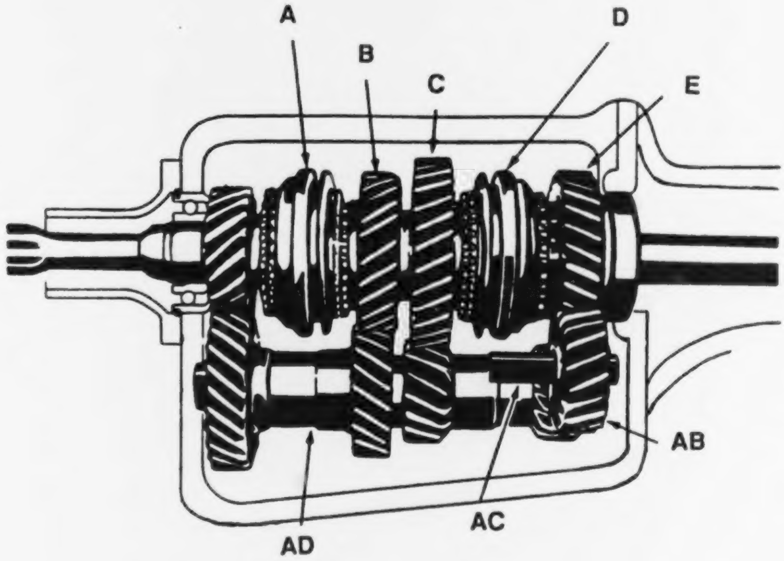
____ 22. The primary function of the counter gear is to mesh with the gear on the input shaft while the transmission is in neutral; by doing so, the counter gear enables drive gears to stop turning even though the input shaft continues to turn.

____ 23. The three-speed transmission uses a first-reverse synchronizer sleeve, while the four-speed transmission uses a first-second synchronizer sleeve.

____ 24. When three and four-speed transmissions are in high gear, the input shaft and main shaft are coupled directly.

____ 25. In a four-speed transmission, the reverse gear is located in the extension housing.

SECTION C. **Shown below are several components of a three-speed transmission. Place the letter of each component in the blank beside its name.**



____ 26. Second speed gear

____ 27. Input shaft gear (main driving gear)

____ 28. Counter gear or cluster gear

____ 29. Reverse idler gear

____ 30. Second and third gear synchronizer assembly

____ 31. Reverse gear

____ 32. First and reverse synchronizer assembly

____ 33. First speed gear

SECTION D. **Select the best answer from the five choices listed.**

____ 34. The most common type of gear used in transmissions is the

a. helical gear.
b. spur gear.
c. either the helical or spur gear.
d. neither the helical or spur gear.
e. drop gear.

____ 35. Gear ratio is determined by

a. dividing the number of teeth on the driven gear by the number of teeth on the driving gear.
b. dividing the number of teeth on the driving gear by the number of teeth on the driven gear.
c. subtracting the number of teeth on the driven gear from the number of teeth on the driving gear.
d. multiplying the number of teeth on the driven gear by the number of teeth on the driving gear.
e. doing none of the above.

____ 36. A gear ratio of 3 to 1 means that, for each revolution of the driven gear, the driving gear will turn

a. 3 times.
b. 1/2 a turn.
c. 1/3 a turn.
d. 2 times.
e. 1 time.

____ 37. In comparison to a 3 to 1 gear ratio, a gear ratio of 2 to 1 will create

a. more torque multiplication and less speed.
b. the same torque multiplication and speed.
c. more torque multiplication and more speed.
d. less torque multiplication and less speed.
e. less torque multiplication and more speed.

____ 38. In a manual transmission, high gear would most likely involve a gear ratio of

a. 5 to 1.
b. 4 to 1.
c. 3 to 1.
d. 2 to 1.
e. 1 to 1.

____ 39. A .7 to 1 gear ratio would most likely be an example of

a. first gear.
b. second gear.
c. third gear.
d. overdrive.
e. none of the above.

____ 40. In a manual transmission, the purpose of a detent is to

a. lubricate gears.
b. protect the transmission from road debris.
c. hold objects in place.
d. lubricate bearings.
e. lubricate the main shaft.

____ 41. In a manual transmission, the purpose of a shim is to

a. slow the driven gear once the driving gear has been disengaged.
b. allow for the synchronized meshing of gears.
c. reduce friction within the transmission.
d. reduce transmission whine.
e. reduce lash or end play between two parts.

____ 42. In a manual transmission, synchronizer hubs with external splines are positioned on the main shaft between the gears. These hubs must

a. turn with the main shaft.
b. be idle when the main shaft turns.
c. turn continuously, whether the main shaft is turning or not.
d. not turn at all.
e. turn at twice the speed of the main shaft.

____ 43. In synchronized transmissions, synchronizer rings

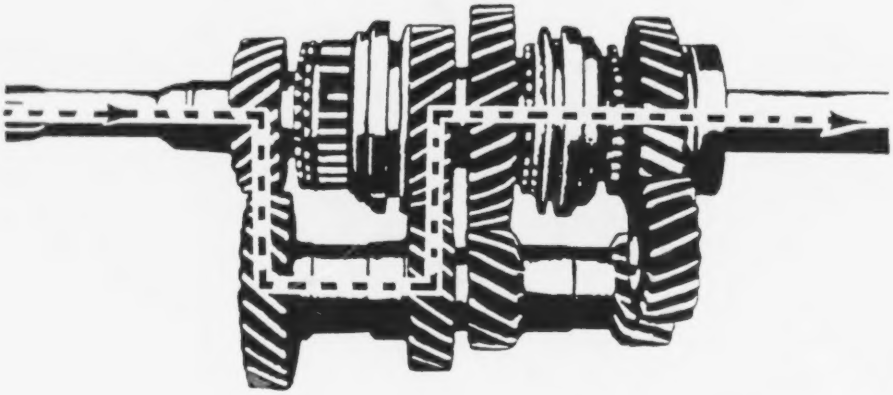
a. grip a smooth cone surface on the gear just prior to gear engagement.
b. cause the synchronizer sleeve and the gear to which the sleeve is engaged to turn at the same time.
c. allow for grind-free shifting.
d. do none of the above.
e. do all of the above.

____ 44. The reverse idler gear

a. spins on the main shaft.
b. shares a bushing with the main shaft.
c. is usually press-fit into the transmission case.
d. does none of the above.
e. does all of the above.

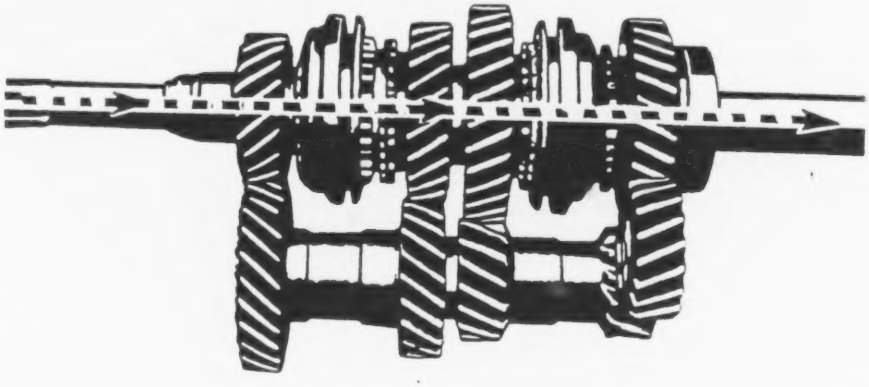
____ 45. Shift forks

a. are welded onto the synchronizer sleeves.
b. ensure that gear teeth do not clash upon engagement.
c. are encased in their own bushing.
d. do none of the above.
e. do all of the above.



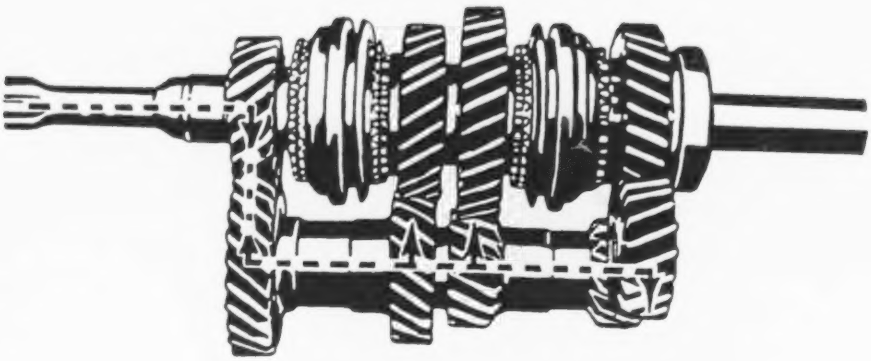
___ 46. The three-speed transmission in the above illustration is in

a. neutral.
b. first gear.
c. second gear.
d. third gear.
e. reverse.



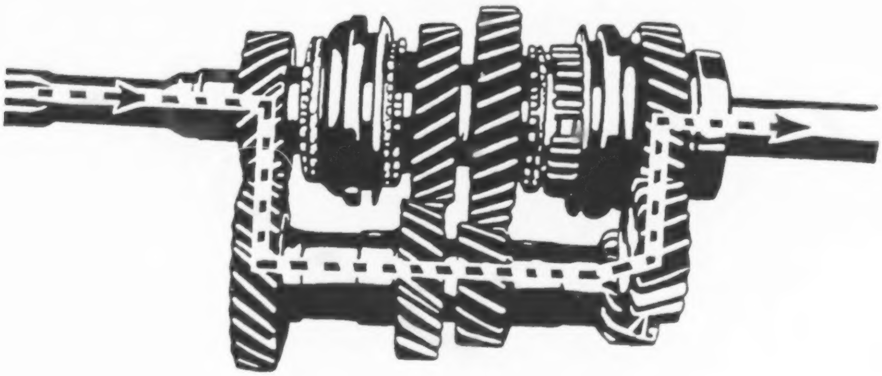
___ 47. The three-speed transmission in the above illustration is in

a. neutral.
b. first gear.
c. second gear.
d. third gear.
e. reverse..



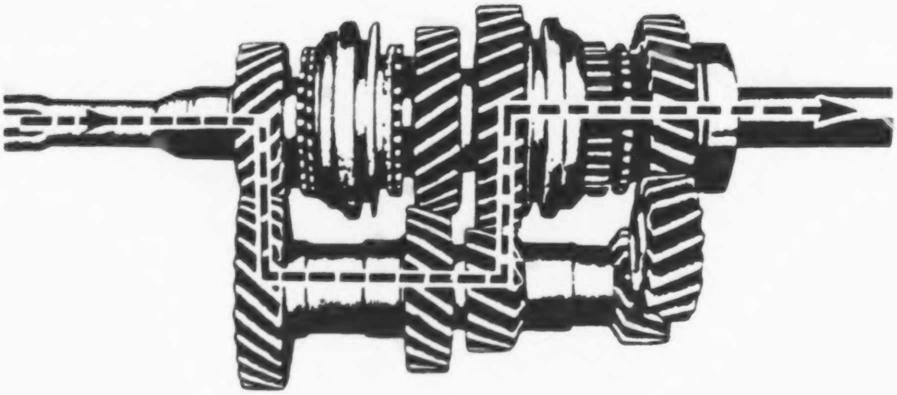
___ 48. The three-speed transmission in the above illustration is in

a. neutral.
b. first gear.
c. second gear.
d. third gear.
e. reverse.



___ 49. The three-speed transmission in the above illustration is in

a. neutral.
b. first gear.
c. second gear.
d. third gear.
e. reverse.



____ 50. The transmission in the above illustration is in

a. neutral.
b. first gear.
c. second gear.
d. third gear.
e. reverse.

(NOTE: The student must obtain a minimum score of _____ on the Unit II Test in order to receive an evaluation for any competencies in the Manual Drive Train and Axles Module.)

ANSWERS TO UNIT II TEST

1. c
2. b
3. d
4. ab
5. a
6. ac
7. ad
8. t
9. f
10. f
11. f
12. t
13. t
14. f
15. t
16. f
17. f
18. f
19. t
20. t
21. f
22. f
23. t
24. t
25. t
26. ac
27. b
28. ad
29. ab
30. a
31. e
32. d
33. c
34. a
35. a
36. a
37. e
38. e
39. d
40. c
41. e
42. a
43. e
44. c
45. d
46. c
47. d
48. a
49. e
50. b

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose, disassemble, and reassemble a manual transmission. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the procedure for performance testing the shift linkage adjustment in a manual transmission (Competency Aa1, Part III of the Unit III Test).

II. Identify the procedure for performance testing the manual transmission (Competency Aa1, Part III of the Unit III Test).

III. Demonstrate the ability to:

a. Diagnose, performance test, and determine needed repairs on a manual transmission (Competency Aa1, JS1-L1-UIII).

Lesson 2. I. Identify transmission problems that do not require transmission removal (Competency Aa1, Part III of the Unit III Test).

II. Identify transmission problems that do require transmission removal (Competency Aa1, Part III of the Unit III Test).

III. Identify safety precautions that should be observed when removing a manual transmission (Competency Aa2, Part I of the Unit III Test).

IV. Identify the procedure for removing a manual transmission (Competency Aa2, Part I of the Unit III Test).

V. Identify terms and definitions that are associated with transmission disassembly (Competency Aa2, Part I of the Unit III Test).

VI. Identify safety precautions that should be observed when working on a manual transmission (Competency Aa2, Part I of the Unit III Test).

VII. Identify the procedure for disassembling a rear-loading manual transmission (Competency Aa2, Part I of the Unit III Test).

VIII. Identify the procedure for cleaning and inspecting transmission components (Competency Aa2, Part I of the Unit III Test).

IX. Demonstrate the ability to:

    a. Remove a manual transmission (Competency Aa2, JS1-L2-UIII).

    b. Disassemble, clean, and inspect manual transmission components (Competency Aa2, JS2-L2-UIII).

Lesson 3. I. Identify the procedure for reassembling a manual transmission (Competency Aa3, Part II of the Unit III Test).

II. Identify safety precautions for reinstalling and adjusting a manual transmission (Competency Aa3, Part II of the Unit III Test).

III. Identify the procedure for reinstalling a manual transmission (Competency Aa3, Part II of the Unit III Test).

IV. Identify procedures for connecting and adjusting shift linkages (Competency Aa3, Part II of the Unit III Test).

V. Demonstrate the ability to:

    a. Reassemble a manual transmission (Competency Aa3, JS1-L3-UIII).

    b. Reinstall and adjust a manual transmission (Competency Aa3, JS2-L3-UIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks C001, C011, C012, C013, C015-C026, and C040.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DIAGNOSING AND PERFORMANCE TESTING THE MANUAL TRANSMISSION

     a. Information outline

     b. Assignment sheets

        AS1-L1-UIII: Procedure for Diagnosing, Performance Testing, and Determining Needed Repairs on a Manual Transmission

     c. Job sheets

        JS-L1-UIII: Diagnosing, Performance Testing, and Determining Needed Repairs on a Manual Transmission

  2. Lesson 2: REMOVING, DISASSEMBLING, INSPECTING, AND CLEANING THE MANUAL TRANSMISSION

     a. Information outline

     b. Assignment sheets

        AS1-L2-UIII: Procedure for Removing a Manual Transmission

        AS2-L2-UIII: Procedure for Disassembling and Inspecting Manual Transmission Components

     c. Job sheets

        JS1-L2-UIII: Removing a Manual Transmission

        JS2-L2-UIII: Disassembling, Cleaning, and Inspecting Manual Transmission Components

  3. Lesson 3: REASSEMBLING AND REINSTALLING THE MANUAL TRANSMISSION

     a. Information outline

b. Assignment sheets

AS1-L3-UIII: Procedure for Manual Transmission Reassembly

c. Job sheets

JS1-L3-UIII: Reassembling a Manual Transmission

JS2-L3-UIII: Reinstalling and Adjusting a Manual Transmission

E. Unit test

F. Answers to unit test

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Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

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Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UIII in conjunction with JS1-L1-UIII; AS1-L2-UIII in conjunction with JS1-L2-UIII; AS2-L2-UIII in conjunction with JS2-L2-UIII; and AS1-L3-UIII in conjunction with JS1-L3-UIII.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

LESSON 1: DIAGNOSING AND PERFORMANCE TESTING THE MANUAL TRANSMISSION

I. Procedure for performance testing shift linkage adjustment

   A. Move the shift lever through all positions and note its smoothness of operation. Improper shift rod adjustment will distort the shift lever's H-pattern.

   B. Start the vehicle (with the instructor's approval) and move the shift lever through all positions. Release clutch pedal slightly to verify forward, neutral, and reverse gear engagement.

II. Procedure for performance testing the manual transmission

   A. Start vehicle (with the instructor's approval) and drive slowly in a low gear. Note any grinding, jumping out of gear, or other unusual activity.

   B. Drive vehicle slowly in reverse and note any grinding, jumping out of gear, or other unusual activity.

   C. Refer to trouble shooting chart for possible causes of unusual noise or improper operation.

   D. Inspect underside of vehicle for leakage.

   E. Drive vehicle normally and shift through all gears. Note any grinding, clash of gear engagement, or other unusual noise or improper operation.

   F. Transmission noises can be located with a stethoscope. The vehicle must be running before a noise can be located; therefore, carefully follow the instructor's safety recommendations.

   G. Refer to trouble shooting chart for possible causes of unusual noise or improper operation.

MANUAL TRANSMISSION TROUBLE SHOOTING CHART

Operates Noisily in Forward Gears

1. Lubricant is low.
2. Improper type of lubricant used.
3. Transmission is misaligned or loose.
4. Synchronizers are worn or damaged.
5. Countergear bearings are worn or damaged.
6. Main drive gear or bearings are worn or damaged.

Operates Noisily in Reverse Gear

1. Worn or broken reverse gear.
2. Transmission cover springs are weak.
3. A worn or broken reverse idler gear or shaft.
4. Linkage not adjusted correctly.

Operates Noisily in All Gears

1. Lubricant is low.
2. Countergear bearings are worn.
3. Damage to clutch gear or mainshaft ball bearings.
4. Damage to speedometer gears.
5. Clutch gear and countershaft drive gear worn or damaged.

Operates Noisily in High Gear

1. Damage to mainshaft bearing.
2. Damage to clutch gear bearing.
3. Damage to speedometer gears.

Operates Noisily in Neutral Gear (with engine on)

1. Damage to mainshaft pilot bearing roller.
2. Damage to clutch gear bearing.

Operates Noisily in All Reduction Gears

1. Lubricant is low.
2. Clutch gear or countershaft drive gears are worn or damaged.

Operates Noisily in Second Gear Only

1. Countergear rear bearings are worn or damaged.
2. Second gear damaged or worn.

Operates Noisily in Low and Reverse Gears Only

1. First and reverse sliding gears are worn or damaged.
2. Low and reverse countergears are damaged or worn.

Operates Noisily in Reverse Only

1. Reverse idler are worn or damaged.
2. Reverse countergear are worn or damaged.
3. Idler bushings are worn or damaged.

Reduction Gears Undergo Excessive Backlash

1. Countergear has excessive end play.
2. Countergear bushings are worn.

Slipping Out of High and/or Second Gear

1. Loose transmission mounting bolts.
2. Control rods causing problems with engine mounts or clutch release lever.
3. Gear fails to engage fully.
4. Control linkage fails to function freely.
5. Mainshaft pilot bearing is damaged.
6. Dirt between transmission case and differential carrier (rear mounted).
7. A loose or broken clutch gear bearing retainer.
8. Transmission misaligned.
9. Springs in transmission cover are weak.
10. Synchronizer assembly worn or broken.

Second Gear Undergoes Excessive Backlash

1. Mainshaft rear bearing not installed in case correctly.
2. Second gear thrust washer is worn.
3. Countergear rear bearing is worn.

Lubricant Leaking

1. Too much lubricant added to transmission.
2. Clutch gear bearing retainer loose or broken.
3. Clutch gear bearing retainer is damaged.
4. Loose cover or damaged gasket.
5. Leakage in the operating shaft seal.
6. Loose idler shaft expansion plugs.
7. Countershaft is loose in case.
8. Bolts have insufficient sealant.

Slipping Out of Low and/or Reverse Gear

1. Splines are improperly mated on inside of first reverse gear and/or external splines on second and third synchronizer sleeve.
2. Damaged first and/or reverse gears (as a result of operating at part engagement).

Clash of forward Gears

1. Clutch fails to release completely.
2. Blocking rings and/or cone surfaces are worn.
3. Blocking ring is broken.
4. Springs in synchronizer assembly are either broken or weak.

Sticks in Gear

1. Lubricant level is low.
2. Clutch fails to release completely.
3. Main drive gear pilot bushing is excessively tight.
4. Synchronizer sleeve or blocking ring is defective.
5. Transmission levers are corroded.

Shifts Hard

1. Wrong type of lubricant.
2. Worn or broken synchronizers.
3. Clutch not adjusted correctly.
4. Shift linkage is damaged or worn.

Jumps Out of Gear

1. Shift linkage is either maladjusted, worn, or loose.
2. Pilot bearing is worn.
3. Main drive gear has excessive end play.
4. Transmission is misaligned or loose.
5. Synchronizer is worn or broken.
6. Detent cam spring is weak.
7. Clutch teeth on main drive gear or synchronize sleeve worn.
8. Output shaft is bent.
9. Detent cam notches are worn.

H. The technician should note the gear position of a fully synchronized transmission at the time the transmission makes noise. A noise that occurs in all gear positions indicates worn or damaged constant-mesh gears or bearings. Noise that occurs in only one gear position can often be attributed to a problem in the particular gear involved. Below is a list of other causes of transmission noise.

1. Insufficient lube transmission
2. Improper type lubricant in the transmission
3. Dirt or metal chips in lubricant
4. Transmission misalignment due to loose mounting bolts
5. Clutch housing misalignment

MODULE: MANUAL DRIVE TRAINS AND AXLES

PROCEDURE FOR DIAGNOSING, PERFORMANCE TESTING, AND DETERMINING NEEDED REPAIRS ON A MANUAL TRANSMISSION

Instructions: **Do the following task on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a logical written procedure for servicing and adjusting the shift linkage of the vehicle to be serviced.

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIAGNOSING, PERFORMANCE TESTING, AND DETERMINING NEEDED REPAIRS ON A MANUAL TRANSMISSION

Equipment:

Hand tools
Hoist
Service light
Service manual
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, determine if the manual transmission's linkage is properly adjusted. ___ ___ ___ ___

   a. Move the shift lever through all positions and note the smoothness of its operation. Improper shift rod adjustment will distort the H-pattern of the shift lever.

   b. Start vehicle (with the instructor's approval) and shift the lever through all positions. Release clutch pedal slightly to verify forward, neutral, and reverse gear engagement.

   c. According to this test, is the shift linkage properly adjusted?

      Yes ___ No ___

      If yes, proceed to step 3.
      If no, proceed to steps d-f.

   d. Complete AS1-L1-UIII.

   e. Following the procedure developed in AS1-L1-UIII, service and adjust the shift linkage.

   f. Repeat steps a-c above.

— — — —

3. Following the procedure outlined below, performance test a vehicle equipped with a manual transmission.

   a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, jumping out of gear, or other unusual activity.

   b. Drive vehicle slowly in reverse and note any grinding, jumping out of gear, or other unusual activity.

   c. Refer to trouble shooting chart for possible causes of unusual noise or improper operation.

   d. Drive vehicle normally and shift through all gears. Note any grinding, clash of gear engagement, or other unusual noise or improper operation.

   e. Noises may be localized with the use of a stethoscope. The vehicle must be running before a noise can be localized; therefore, carefully follow the instructor's safety recommendations.

   f. Refer to trouble shooting chart for possible causes of unusual noise or improper operation.

   g. Record results of performance test.

   h. Recommend steps to correct any problems determined to be in the manual transmission.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa1. Final evaluation for Aa1 will be made at the end of JS1-L2-UX).

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

LESSON 2: REMOVING, DISASSEMBLING, INSPECTING, AND CLEANING THE MANUAL TRANSMISSION

I. Problems not requiring transmission removal

(NOTE: Sections I and II of this lesson merely distinguish between problems that require transmission removal and those that do not. A more complete discussion of transmission diagnosis appears in Lesson 3 of this unit.)

A. When the transmission is leaking lubricant, the transmission case will be wet with a thick, aromatic oil. Listed below are problems that cause leaks. All of these problems can be corrected without removing the transmission.

1. Too much lubricant in the transmission

2. Side or inspection cover loose or a defective gasket

3. Loose extension housing or defective gasket

4. Defective rear seal or bushing

B. Misadjustment of the shift linkage can result in hard shifting or grinding and clashing of the gears during shifting. Shift linkage misadjustment may even cause the car to jump out of gear. The shift linkage can be readjusted without removing the transmission.

C. A growling sound in all gears may indicate that lubricant is too low or too thin. Lubricant can be added without removing the transmission. Refer to manufacturer's specifications for correct type of lubricant to add and the level to which the transmission should be filled.

D. If transmission shifts hard in cold weather, the lubricant may be too thick. Lubricant can be changed without removing the transmission. Refer to manufacturer's specifications for correct type of lubricant.

II. Problems requiring transmission removal

A. If the transmission jumps out of gear (even though the shift linkage is not misadjusted), it must be removed and its internal parts inspected.

(NOTE: A worn pilot bushing can cause the transmission to jump out of gear, but correction of this problem would still require transmission removal.)

B. If gears clash on engagement (making a loud grinding sound during shifting) even though the linkage is properly adjusted, the cause may well be a problem with the internal workings of the transmission. Correction of such a problem requires transmission removal.

(NOTE: A misadjusted shift linkage can cause gears to clash upon engagement. Inspect shift linkage before removing transmission.)

C. If the transmission is noisy while in operation (making growling or rumbling noises), the gears or bearings may be defective. Determining the cause of such noise requires removal, disassembly, and inspection of the transmission.

(NOTE: As was stated above, improper lubricant or low lubricant level may cause transmission noise. Check lubricant before removing transmission.)

D. If the transmission case must be replaced because of damage (for example, if cracks appear in the case casting), the transmission must be removed.

E. If wetness occurs at the lower front of the transmission, a defective input shaft seal or bearing may be causing a leak. Repair will require that the transmission be removed.

III. Safety precautions for transmission removal

A. The technician must work underneath a vehicle in order to remove its transmission. The vehicle must, therefore, be properly supported on jackstands or a hydraulic lift rack. Refer to manufacturer's recommendations for safe locations to place jackstands.

B. Falling debris from the vehicle's underside is very hazardous. The technician should, therefore, always wear safety goggles or glasses when removing a transmission.

C. Some transmissions may weigh 100 pounds or more, therefore, great care must be taken when lowering a transmission from a vehicle. Use of a transmission jack may be required.

D. The transmission case is made of cast iron or aluminum and may have sharp edges. The technician must be careful to avoid cuts. He or she may need to wear protective gloves.

IV. Procedure for removing a manual transmission

A. Place the car securely on safety stands or lift with hoist.

B. Drain the lubricant from the transmission (if possible).

C. Remove the drive shaft using the procedure outlined below.

1. Remove the U-bolts or straps.
2. Pry the drive shaft forward so that it separates from the differential.
3. Wrap the rear U-joint with tape.
4. Slip the drive shaft out of the transmission.

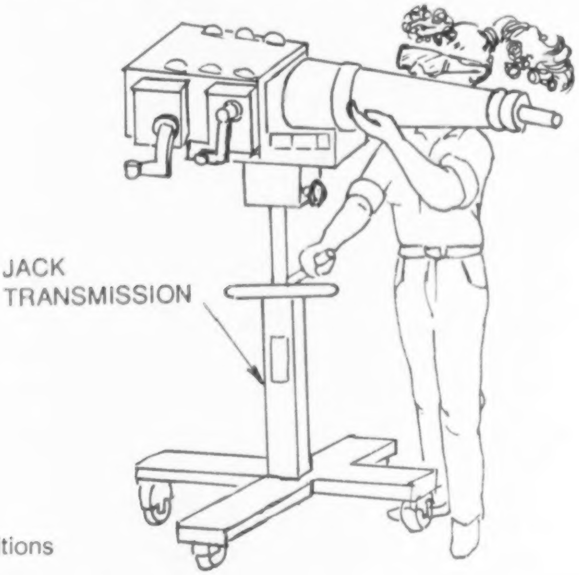
D. Disconnect the shift linkage, speedometer cable, and any wire connectors from the transmission.

E. Stop lubricant leakage from the transmission extension housing by inserting an old drive shaft yoke or rag.

F. Support engine and remove transmission mount to crossmember bolts. Remove parking brake cable if necessary. Remove crossmember bolts and crossmember.

G. Remove transmission to bellhousing upper bolts and replace with guide studs.

H. Remove transmission to bellhousing; then, lower bolts and carefully remove transmission. (Use a transmission jack if necessary.)



V. Terms and definitions

A. End play--The distance an object can move back and forth in line with the axis of rotation.

B. Lash--Looseness between two transmission parts.

C. Tolerance--The variation of fit between two parts. Tolerance is expressed as a minimum and maximum measurement.

VI. Safety considerations for working on manual transmissions

A. The technician's fingers can be seriously injured when he or she is working on a transmission. Case castings often have sharp edges which can easily cut fingers. If the technician encounters sharp edges, he or she should wear protective gloves. Fingers can also be easily pinched during removal of the extension housing and main shaft assembly.

B. When driving counter gear shafts and reverse idler shafts, use only soft metal drift punches and wear safety glasses to protect eyes against flying metal chips.

C When removing snap rings, use properly designed snap ring pliers. Never attempt to pry a snap ring with a screwdriver. Be careful not to distort the snap ring by over-spreading it.

D. A manual transmission contains many needle bearings, washers, snap rings, and other small but costly pieces. During transmission service, put all such parts into bags or small boxes. When washing larger transmission components, be sure no small parts are clinging to them. Also check the metal debris magnet (located in the transmission case) for small parts.

E. Most transmission components are precision machined. Dropping them (or even storing them in piles) can cause serious damage. Never allow any part to fall or roll off the workbench.

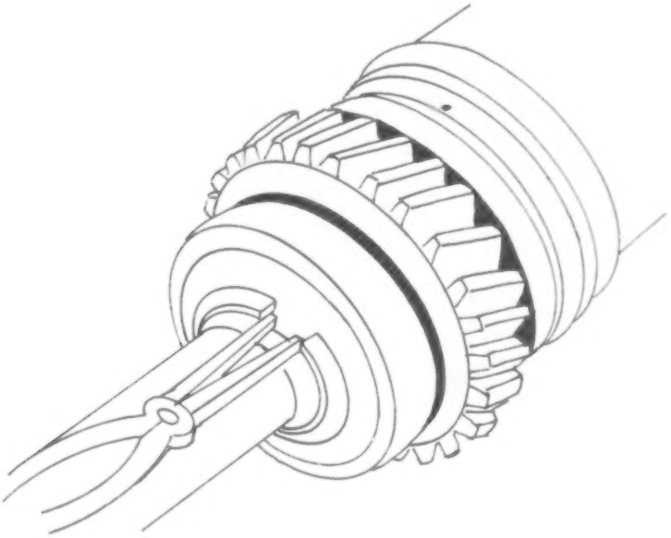
F. Proper safety shoes should always be worn during transmission service.

VII. Procedure for manual transmission disassembly (rear-loading types)

A. Drain any remaining gear lube by tipping the transmission. Lubricant will run out of the extension housing into a drain pan.

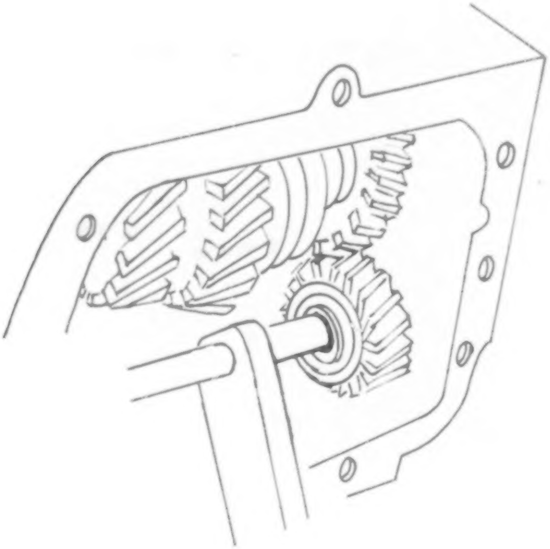
B. Shift transmission into neutral and remove side plate and shift forks.

C. Remove input shaft retaining collar. Remove input shaft snap ring and remove front ball bearing.



D. Remove speedometer driver gear assembly from extension housing.

E. Remove "E" clip from reverse idler shaft, if so equipped. Some models may require that the reverse idler shaft be driven out of the case at this time.

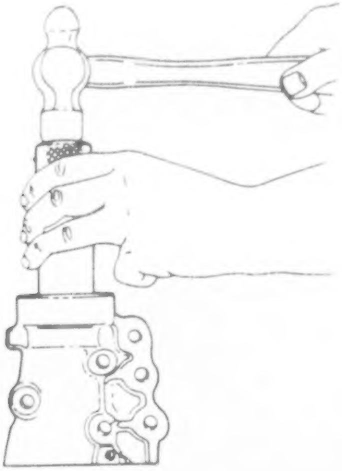


F. Remove extension housing bolts; then, carefully remove input shaft and main shaft/extension housing assembly as one unit.

G. Remove input shaft and gear from main shaft assembly.

(NOTE: Roller bearing will fall out during input shaft and gear removal. Be sure to store the bearing in an appropriate place.)

H. Expand rear ball bearing snap ring, and remove main shaft assembly from extension housing.



I. Drive counter gear shaft out of the back of the case. Use dummy shaft to retain needle bearings. (If dummy shaft is not available, be sure to collect all needle bearings.) Remove counter gear, bearings, and thrust washers.

J. Drive out reverse idler shaft through rear of case (if shaft was not previously removed) and remove reverse idler gear and thrust washer.

K. If directed by the instructor, remove front seal from the input shaft bearing collar and the rear seal and bushing from the extension housing.

L. Remove speedometer gear from the rear of the main shaft.

M. When necessary, remove snap rings to allow removal of rear ball bearing, gears, hubs, and spacers.

N. Disassemble side plate shift fork and detent assembly.

VIII. Procedures for cleaning and inspecting transmission components

A. Wash all components with solvent and blow them dry with compressed air.

(NOTE: During this step, be very careful to collect all small parts and bearings.)

B. Inspect case and extension housing for cracks, damaged bearing bores, and damaged threads. Check metal debris magnet (if available) for excessive build up of chips, which can indicate damage to transmission components. Remove nicks or burrs from machined mating surfaces.

C. Check ball bearings for roughness by lubricating them with light oil and turning races by hand.

D. Inspect loose needle and roller bearings for wear and damage.

E. Inspect all thrust washers for wear and damage.

F. Inspect reverse idler gear bushing and shaft for wear or damage. Inspect counter gear shaft for wear.

G. Inspect all other gears for bushing damage or wear.

H. Inspect the condition of all gear teeth. Worn or chipped teeth require gear replacement.

I. Inspect synchronizer hubs, detent blocks, and springs for damage or wear.

J. Inspect brass synchronizer rings (blocker rings) for damage or wear.

K. Check synchronizer shift sleeves for worn or damaged internal teeth. Check for smooth sliding fit on synchronizer hubs.

L. Check shift forks and detent assemblies for breakage or wear.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR REMOVING A MANUAL TRANSMISSION

Instructions: **Do the following task on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the manual transmission from the vehicle to be serviced.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR DISASSEMBLING AND INSPECTING MANUAL TRANSMISSION COMPONENTS

Instructions: Do the following task on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model and year of the vehicle to be serviced.

2. Develop a written procedure for disassembling the manual transmission to be serviced.

3. Determine and record the critical dimensions or clearances for manual transmission components. Develop a written procedure for checking the critical dimensions or clearances of each manual transmission component.

JS1-L2-UIII

MODULE: MANUAL DRIVE TRAIN AND AXLES

REMOVING A MANUAL TRANSMISSION

Equipment:

Hand tools
Hoist
Serviceable vehicle
Transmission jack
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Complete AS1-L2-UIII. ___ ___ ___ ___

2. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

3. Place the car securely on safety stands or lift with hoist.

   (CAUTION: Remove the negative battery cable before raising the vehicle.) ___ ___ ___ ___

4. Following the steps outlined below and the procedure developed in AS1-L2-UIII, remove the manual transmission.

   a. Have the instructor approve the entire procedure developed in AS1-L2-UIII before starting. ___ ___ ___ ___

   b. Make sure engine is properly supported before removing transmission cross member.

   c. Tape the U-joint caps on the trunnion ends as soon as the drive shaft is removed.

   d. Install a slip yoke or grease retainer in back of the transmission to prevent fluid loss during removal.

e. Using the procedure developed in AS1-L2-UIII, remove the manual transmission from the vehicle.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Aa2. Final evaluation will be made at the end of JS1-L2-UXI.)

JS2-L2-UIII

MODULE: MANUAL DRIVE TRAIN AND AXLES

DISASSEMBLING, CLEANING, AND INSPECTING MANUAL TRANSMISSION COMPONENTS

Equipment:

Hand tools
Snap ring pliers
Drain pan
Special tools identified in AS2-L2-UIII
Safety glasses

Procedure:

		Evaluation 3	 2	 1	 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__	__	__	__
2.	Inspect the transmission for leakage. Record results.	__	__	__	__
3.	Complete AS2-L2-UIII.	__	__	__	__
4.	Drain the transmission fluid from the manual transmission. Observe and record the condition of the fluid.	__	__	__	__
5.	Following the procedure developed in AS2-L2-UIII, disassemble the manual transmission.	__	__	__	__
6.	Clean manual transmission components and case with safety solvent and blow dry.	__	__	__	__

7. Inspect all manual transmission components for damage. Record results below. _ _ _ _

(HINT: Refer to item 3 of AS2-L2-UIII for transmission specifications.)

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Aa2. Final evaluation for Aa2 will be made at the end of JS1-L2-UXI.)

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

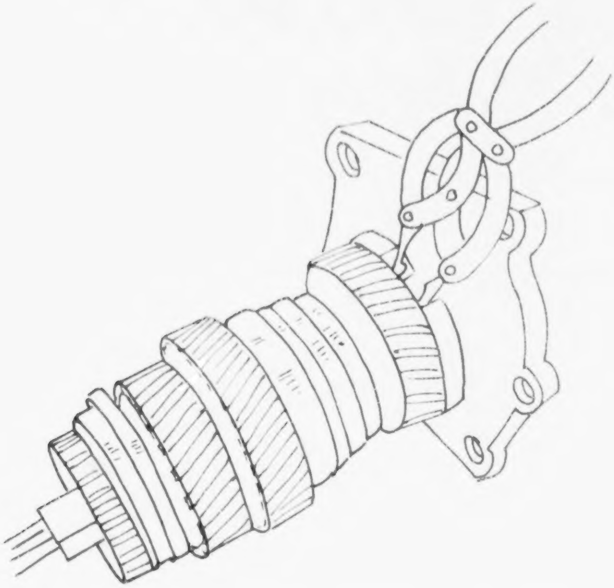
LESSON 3: REASSEMBLING AND REINSTALLING THE MANUAL TRANSMISSION

I. Procedure for manual transmission reassembly

A. Be sure that gasket material is completely removed from case, extension housing, side plate, and input shaft bearing retaining collar.

B. Be sure that all damaged or missing parts have been replaced as directed by the instructor.

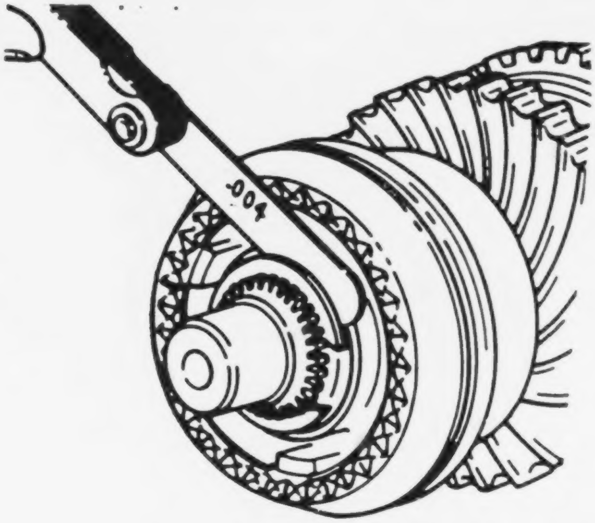
C. Install new extension-housing bushing, rear seal, and front seal (if previously removed).



D. Install spacers, hubs, gears, rear ball bearings, and snap rings. (When installing these items, reverse the order in which they were removed during step VII-M.) Make clearance measurements with feeler gauge as indicated in repair manual

E. Compare clearance measurements with specifications and make needed adjustments. Clearances are adjusted by using either shims or snap rings of different thicknesses. Lubricate all components prior to final assembly.

(NOTE: Be sure to align marks on synchronizer sleeve with those on hub, if indicated.)



Courtesy of General Motors Corporation

F. Install speedometer gear on main shaft. Expand snap ring in extension housing and install main shaft.

G. Pack needle bearings into counter gear (cluster gear) using heavy grease. Be sure that spacers are in position.

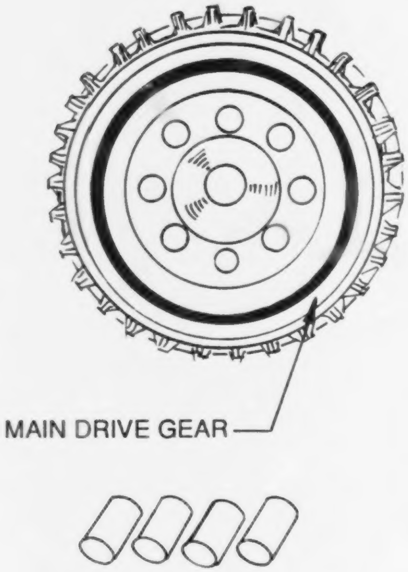
H. Slide counter gear shaft through to align needle bearings. (Use dummy shaft, if available, and leave in place.)

I. Apply grease to counter gear thrust washers and place them inside transmission case with tangs engaged to case slots. Carefully move counter gear into position in the case and slide counter gear shaft through from the rear.

(NOTE: Be sure that thrust washers do not come out of position and that no needle bearings are pushed through. Turn shaft so that alignment woodruff key or pin aligns with case hole. Drive shaft in place so that it does not protrude from rear of case. Check end play as required by manufacturer.)

J. Lubricate and install reverse idler gear, shaft, and thrust washers. Do not install "E" ring (if used) at this time.

K. Pack main shaft pilot roller bearings into machined cavity in input shaft. Place high-gear synchronizer ring in position on hub and install input shaft on front of main shaft.



L. Slide input shaft/main shaft assembly through rear of case with gasket in position.

M. Seat case with extension housing. Be sure bolt holes in gasket are aligned, and thread a couple of bolts into the case to hold extension housing in place.

N. Install front ball bearing and snap rings.

O. With gasket in position, install front bearing retaining collar and bolts. Be sure that high gear synchronizer ring is properly engaged with detent keys. Tighten all bolts to manufacturer's specifications. Rotate input shaft and main shaft to be sure there is no binding. Make end play measurements as required and adjust as indicated in manual.

P. Position reverse idler gear and install "E" ring if so equipped.

Q. Lubricate and assemble side plate and shift fork/detent mechanism. Adjust as required by manufacturer.

R. Slide synchronizer sleeves into correct position for side plate/shift fork installation (usually neutral position). Install side plate gasket and side plate. (Be sure that shift forks engage synchronizer sleeves.) Tighten side plate bolts to specifications.

S. Test all shift positions by operating shift levels while turning input shaft.

T. Install speedometer driven gear assembly in extension housing.

II. Safety precautions for transmission installation and adjustment

A. Since the technician must work underneath the vehicle while removing the transmission, the vehicle must be properly supported on jackstands or a hydraulic lift rack. Refer to manufacturer's recommendations for safe locations for jackstands.

B. Debris falling from the vehicle's underside is a serious hazard; therefore, the technician should wear safety goggles.

C. The transmission may weigh 100 pounds or more; therefore, careful consideration must be given to raising the transmission into the vehicle. Use of a transmission jack may be required.

D. The transmission case is made of cast iron or aluminum and may have sharp edges. Care must be taken to avoid cuts. The technician may have to wear protective gloves.

E. During the installation procedure, the technician may have difficulty getting the transmission input shaft to engage the clutch disc and pilot bushing. Care must be taken to avoid damaging the clutch disc by allowing the transmission to hang by the input shaft. Never draw the transmission in place with bolts; doing so may break off the ears of the transmission case.

III. Procedure for reinstalling the manual transmission

A. Place the car securely on safety stands or lift it with a hoist.

B. Prepare the transmission for installation by applying a thin coat of heavy grease to the pilot end of the input shaft and also to the collar of the front bearing retainer. If available, insert a drive shaft yoke into the extension housing and lock the transmission into any gear.

C. Place guide studs in the upper bolt holes on the bellhousing.

D. Carefully raise transmission and insert input shaft through throw-out bearing (release bearing). Use guide studs to align transmission, and slide transmission toward bellhousing. If input shaft splines will not engage clutch disc splines, rotate by turning the drive shaft yoke until splines engage. Slide transmission in until it rests against bellhousing.

(NOTE: Never draw the transmission into position with bolts. Doing so can break the ears off the transmission case. Failure of the transmission to seat fully may indicate misalignment of the clutch disc with the pilot bushing. Refer to clutch alignment procedures in Unit VI of this module.)

E. Remove guide studs and install bolts. Tighten to manufacturer's specification.

F. Inspect condition of transmission crossmember mount. If the mount is oiled, softened, or broken, replace it. Install on extension housing.

G. Install transmission crossmember and parking brake cable (if required).

H. Lower engine support until transmission rear mount rests on crossmember. Move transmission laterally until bolts can be installed through crossmember into transmission mount. Tighten to specifications.

I. Install the drive shaft using the below procedure.

1. Remove the yoke from the extension housing (if used).
2. Remove the tape from the rear U-joint bearing cups.
3. Apply lubricant to front drive shaft yoke.
4. Insert yoke into transmission extension housing.
5. Insert rear U-joint into differential companion flange.
6. Install U-bolts and tighten evenly.

J. Connect speedometer drive cable and any wire connectors to transmission.

K. Remove side plug from transmission case and fill to within 1/4 inch from hole with correct gear lubricant. Replace plug.

L. Inspect transmission for lubricant leaks.

IV. Procedure for connecting and adjusting shift linkages

A. Shift transmission into neutral by turning shift levers.

B. Inspect condition of shifter lever mechanism, shift rods, and bushings. Replace worn or defective parts.

C. Insert a metal pin or nail through alignment holes in shift levers and lock shifter in neutral position. (Column shifter may have to be held in midtravel position.)

D. Adjust shift rod length so that rod ends slip into transmission shift levers without moving the levers.

E. Apply grease to shift rod ends or bushings and install rods on shift levers with washers and spring pins.

F. Remove neutral alignment pin from shifter mechanism.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR MANUAL TRANSMISSION REASSEMBLY

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Determine and record all critical clearances that must be measured during manual transmission reassembly.
3. Develop a written procedure for checking each critical clearance recorded in item 2 above. In the procedures, identify the type of tool required to check each clearance.
4. Develop a written procedure for reassembling the transmission.
5. Determine and record all torque specifications related to reassembly of the manual transmission.
6. Determine and record the type and quantity of fluid needed to refill the transmission.

JS1-L3-UIII

MODULE: MANUAL DRIVE TRAIN AND AXLES

REASSEMBLING A MANUAL TRANSMISSION

Equipment:

Hand tools
Snap ring pliers
Special tools as outlined in AS1-L3-UIII
Torque wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, reassemble the manual transmission. ___ ___ ___ ___

   a. Be sure that gasket material is completely removed from the case, extension housing, side plate, and input shaft bearing retaining collar.

   b. Be sure that all damaged or missing parts have been replaced as directed by the instructor.

   c. Complete AS1-L3-UIII.

   d. Using the procedure developed in AS1-L3-UIII, reassemble the manual transmission.

      (NOTE: During reassembly, lightly coat all gears and bearings with appropriate fluid.)

   e. Bench test the manual transmission to ensure that all parts turn freely and shift smoothly in all gear positions.

   Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Aa3. Final evaluation for Competency Aa3 will be made at the end of JS1-L3-UXI.)

JS2-L3-UIII

MODULE: MANUAL DRIVE TRAINS AND AXLES

REINSTALLING AND ADJUSTING A MANUAL TRANSMISSION

Equipment:

Hand tools
Hoist
Service light
Transmission jack
Torque wrench
Safety glasses

Procedure:	Evaluation 3	 2	 1	 N
1. Complete AS1-L2-UIII.	___	___	___	___
2. Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
3. Place the car securely on safety stands or lift with a hoist.	___	___	___	___
4. Following the procedure outlined below, reinstall the manual transmission.	___	___	___	___

   a. Reversing the procedure developed in AS1-L2-UIII, reinstall the manual transmission.

   b. Tighten transmission and linkage mounting bolts to torque specifications outlined in service manual.

   c. Install drive shaft.

   d. Fill manual transmission with fluid. Observe correct fluid level.

   e. Adjust (center) shift linkage.

   f. Align power train mounts.

5. Using the procedure outlined in JS1-L1-UIII, test the adjustment of the shift linkage and operation of the manual transmission. Record observations. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Aa3. Final evaluation for Aa3 will be made at the end of JS1-L3-UXI.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT III: MANUAL TRANSMISSION DIAGNOSIS AND REPAIR

UNIT III TEST

PART I. REMOVING, CLEANING, AND INSPECTING MANUAL TRANSMISSION COMPONENTS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. End play is the distance that an object can move back and forth in line with the axis of rotation.

____ 2. Lash refers to looseness between two manual transmission parts.

____ 3. Tolerance refers to the amount of rpm the main shaft can achieve without being damaged.

____ 4. Before transmission disassembly, the technician should flush out gear lubricant with pressurized water.

____ 5. Before removing the side plate and shift forks, the technician should put the transmission into reverse.

____ 6. Some vehicles may require that the reverse idler shaft be driven out of the case when the E clip is removed from it.

____ 7. The technician should wear protective gloves if he or she encounters sharp edges on transmission case castings.

____ 8. The technician should remove input shaft and main shaft/extension housing assembly as one unit.

____ 9. Snap rings should be pried loose with a screwdriver.

____ 10. While working on a transmission, the technician should store small parts in bags, boxes, or muffin tins.

____ 11. To protect him or herself from falling debris, the technician should wear safety glasses when working on the underside of a vehicle.

____ 12. When driving the counter gear shaft out of the back of the case, the technician should use a dummy shaft to retain needle bearings.

____ 13. Before disassembling a manual transmission, the technician should drain the gear lube by tipping the transmission.

____ 14. The average weight of a transmission is 50 pounds.

SECTION B. Select the best answer from the five choices listed.

____ 15. After the transmission is disassembled, all components should be

a. washed in solvent and dried with a clean shop towel.
b. washed in clear tap water and dried with a clean shop towel.
c. washed in kerosine and blow dried with compressed air.
d. washed in solvent and blow dried with compressed air.
e. washed in soapy water and blow dried with compressed air.

____ 16. Excessive buildup of metal chips on the metal debris magnet indicates

a. that transmission components are wearing at a normal rate.
b. that transmission components may be damaged.
c. that there is too much lubricant in the transmission.
d. the wrong type of lubricant is being used in the transmission.
e. none of the above.

____ 17. A gear that has worn or chipped requires

a. that the broken teeth be sanded down.
b. that new teeth be welded to the gear.
c. no attention unless the amount of worn or chipped teeth is excessive.
d. replacement of the gear.
e. any of the above, depending on the extent of gear damage.

____ 18. The technician should make sure that synchronizer shift sleeves

a. fit extremely loose against the synchronizer hubs.
b. have a smooth sliding fit on the synchronizer hubs.
c. are fastened securely to the synchronizer hubs.
d. do not come into contact with the synchronizer hubs.
e. are securely welded to the synchronizer hubs.

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit III Test in order to receive an evaluation for Competency Aa2.)

PART II. REASSEMBLING AND INSPECTING THE MANUAL TRANSMISSION

SECTION A. Select the best answer from the five choices listed.

____ 19. When installing spacers, hubs, gears, rear ball bearings, and snap rings on the main shaft, the technician should make clearance measurements with

a. a feeler gauge.
b. a caliper.
c. a ruler.
d. a compass.
e. none of the above.

____ 20. When installing spacers, hubs, gears, rear ball bearings, and snap rings on the main shaft, the technician can adjust clearances by

a. either grinding down or applying molding to snap rings.
b. bending parts slightly in a vice.
c. adjusting the main shaft.
d. using different snap ring thicknesses.
e. doing none of the above.

____ 21. When reassembling a manual transmission, the technician should align marks on the synchronizer sleeve with

a. those on the hub, if indicated.
b. those on the main shaft, if indicated.
c. those on the gears, if indicated.
d. all of the above.
e. none of the above.

____ 22. During transmission reassembly, the technician should pack needle bearings into the counter gear using

a. heavy grease.
b. light grease.
c. solvent.
d. motor oil.
e. none of the above.

____ 23. When reassembling a manual transmission, the proper time to install the E ring is

a. before the reverse idler gear has been lubricated and installed.
b. immediately after packing needle bearings into the counter gear.
c. immediately after positioning the reverse idler gear.
d. immediately after installing the main shaft.
e. immediately before installing front ball bearings and snap rings.

____ 24. During transmission reassembly, the speedometer gear should be installed on

a. the counter gear.
b. the hub.
c. the E ring.
d. input shaft.
e. in none of the above locations.

____ 25. After installing front bearing retaining collar and bolts in the manual transmission, the technician should

a. be sure that the high-gear synchronizer is properly engaged with detent keys.
b. tighten all bolts to manufacturer's specifications.
c. rotate input shaft to make sure there is no binding.
d. do all of the above.
e. do none of the above.

____ 26. During transmission reassembly, the speedometer gear assembly should be installed

a. on the counter gear.
b. on the hub.
c. on the E ring.
d. in the extension housing.
e. in none of the above locations.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit III Test in order to receive an evaluation for Competency Aa3.)

PART III. DIAGNOSING THE MANUAL TRANSMISSION

SECTION A. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 27. Technician I says that too much lubricant in the transmission can cause leakage.

Technician II says that a defective rear seal or bushing can be serviced only if the transmission is removed.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 28. Technician I says that a growling sound can indicate that the transmission lubricant is too thick.

Technician II says that the transmission must be removed before adjusting shift linkage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 29. Technician I says that, if transmission will not shift in cold weather, the lubricant may be too thick.

Technician II says that a worn pilot bushing could cause the transmission to jump out of gear.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that, if gears clash on engagement, correction of the problem may require removal of the transmission.

Technician II says that a likely cause of transmission noise is defective gears or bearings.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 31. Technician I says that a maladjusted shift linkage may cause gears to clash on engagement.

Technician II says that, when attempting to diagnose transmission noise, transmission lubricant should be checked before transmission removal.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 32. Technician I says that replacement of the transmission case will not require the removal of the transmission.

Technician II says that repair of a defective input shaft seal or bearing will require removal of the transmission.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 33. Technician I states that, if the transmission is noisy in second gear only, the cause could be dirt between the transmission case and clutch housing (front mounted) or between the transmission case and differential carrier (rear mounted).

Technician II states that noise in all gears could be caused by loose transmission mounting bolts.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 34. Technician I states that damaged speedometer gears can cause the transmission to be noisy in high gear.

Technician II states that a damaged clutch bearing can cause the transmission to be noisy in high gear.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 35. Technician I says that hard shifting may be caused by corroded transmission levers.

Technician II says that a low transmission lubricant level can cause the transmission to stick in gear.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on Part III of the Unit III Test in order to receive an evaluation for Competency Aa1.)

ANSWERS TO UNIT III TEST

1. t
2. t
3. f
4. f
5. f
6. t
7. t
8. f
9. f
10. t
11. t
12. t
13. t
14. f
15. d
16. b
17. d
18. b
19. a
20. d
21. a
22. a
23. c
24. e
25. d
26. d
27. a
28. d
29. c
30. c
31. c
32. b
33. d
34. b
35. c

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IV: COMPONENTS OF THE CLUTCH ASSEMBLY AND HOW THEY OPERATE

UNIT OBJECTIVE

After completing this unit, the student should be able to identify clutch assembly components and the principles by which they operate. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with clutch assembly components and their operation (Competencies Z1 and Z2, Unit IV Test).

II. Identify the functions of clutch components (Competencies Z1 and Z2, Unit IV Test).

III. Identify the processes and principles by which the clutch assembly functions (Competencies Z1 and Z2, Unit IV Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IV: COMPONENTS OF THE CLUTCH ASSEMBLY AND HOW THEY OPERATE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: CLUTCH ASSEMBLY COMPONENTS AND THEIR OPERATION

    a. Information outline

    b. Assignment sheets

      AS1-L1-UIV: Clutch Assembly Components and Their Operation

E. Unit test

F. Answers to unit test

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Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

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Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UIV before doing the Unit IV Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.

   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IV: COMPONENTS OF THE CLUTCH ASSEMBLY AND HOW THEY OPERATE

LESSON 1: CLUTCH ASSEMBLY COMPONENTS AND THEIR OPERATION

I. Terms and definitions

  A. Clutch diaphragm spring--A dish-shaped piece of spring steel that puts tension on the clutch pressure plate.

  B. Clutch disc--A steel disc faced with friction material. The clutch disc is compressed between the clutch pressure plate and the engine flywheel. The center portion is splined in order to relay turning power to the transmission's input shaft.

  C. Clutch pedal free travel--The distance that the clutch pedal must be depressed before the throw-out bearing begins to contact the clutch release fingers on the pressure plate.

  D. Clutch pressure plate--A formed steel assembly, which contains springs, a steel plate, and a steel cover. The clutch pressure plate compresses the clutch disc against the engine flywheel.

  E. Clutch release fork--A steel fork that operates the throw-out bearing (release bearing) by pivioting on a ball stud in the bellhousing. A linkage connects the release fork to the clutch pedal.

  F. Multiple disc clutch--A type of clutch containing several friction discs. Some are driving discs and some are driven discs.

  G. Pilot bushing (bearing)--A friction-reducing device, which is pressed into a machined cavity in the engine crankshaft. The pilot bushing supports and centers the transmission input shaft.

  H. Pressure plate--Another term for the clutch pressure plate.

  I. Throw-out bearing (release bearing)--A caged and sealed bearing that slides back and forth on the transmission input shaft bearing retainer collar. The throw-out bearing is operated by the release fork and applies pressure to the clutch pressure plate release fingers.

II. The function of clutch assembly components

  A. The clutch disc is splined to the transmission input shaft (clutch shaft). The disc is faced with friction material. When the disc is compressed between the engine flywheel and pressure plate, the friction material allows the disc to deliver turning power to the transmission.

  B. The flywheel, bolted to the engine crankshaft, provides a smooth surface against which the clutch disc can be compressed. Threaded holes provide a means of mounting the pressure plate assembly.

C. Clutch pressure plate

1. The pressure plate contains a spring-loaded, smooth steel surface, which applies pressure to the clutch disc. The disc, sandwiched between the pressure plate and flywheel, can then deliver the turning power to the transmission input shaft.

   (NOTE: Pressure plates are identified by the following characteristics: the make of vehicle on which the pressure plate is used; the diameter and design of the pressure plate; and the amount of force the pressure plate applies to the clutch disc.)

2. When the clutch pedal is depressed, clutch release fingers in the pressure plate pull the plate away from the disc. This pulling away of the plate relieves pressure on the clutch disc, thus disengaging the engine's turning power from the transmission.

D. In a manual transmission, the throw-out bearing is a caged, sealed, and permanently lubricated bearing that slides back and forth on the input shaft collar. When the clutch pedal is depressed, the throw-out bearing presses on the pressure plate release fingers.

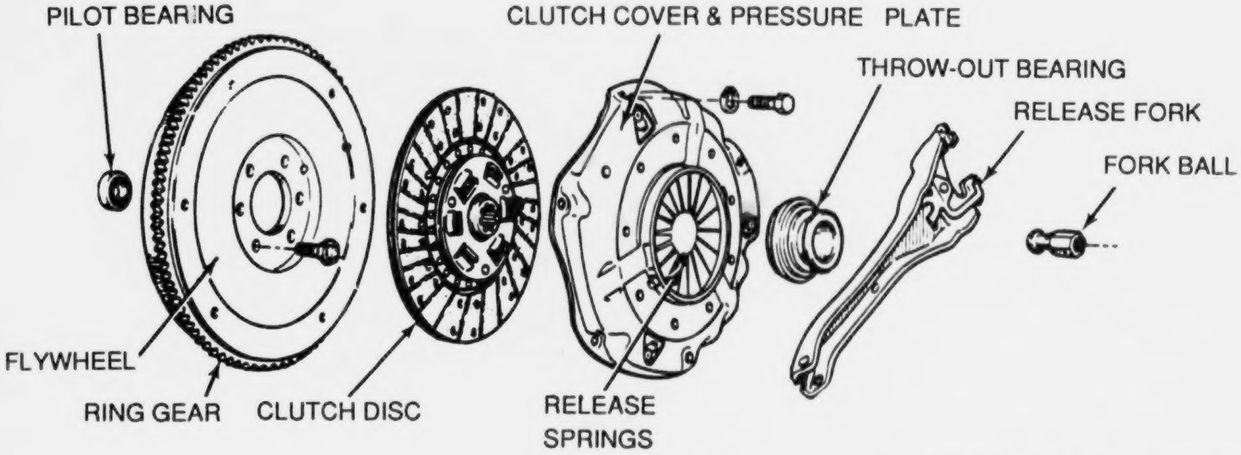
E. The release fork pivots on a ball stud in the bellhousing and slides the throw-out bearing back and forth on the input shaft collar.

F. The pilot bushing/bearing is pressed into a machined cavity in the rear of the engine crankshaft. The pilot bushing centers and supports the transmission input shaft, thus preventing the shaft from wobbling. The pilot bushing also centers and supports the clutch disc, which slides on the shaft.

G. The bellhousing covers the clutch assembly and provides a mounting surface for the transmission. The bellhousing contains a ball stud on which the release fork pivots.

H. The clutch linkage connects the clutch pedal to the release fork. The linkage also allows for the free travel of the clutch pedal.

III. Operation of clutch assembly components

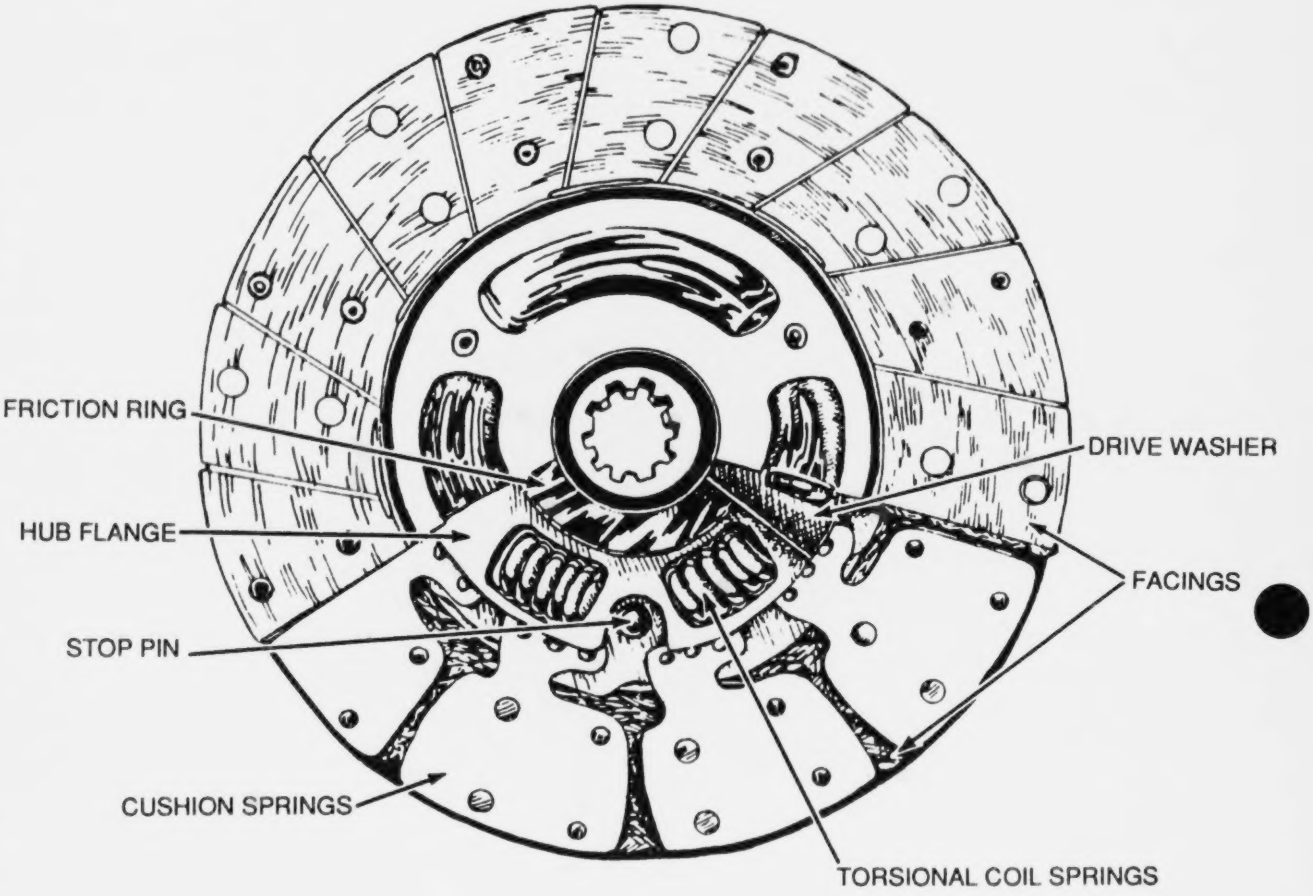

PILOT BEARING
CLUTCH COVER & PRESSURE PLATE
THROW-OUT BEARING
RELEASE FORK
FORK BALL
FLYWHEEL
RING GEAR
CLUTCH DISC
RELEASE SPRINGS

Courtesy of General Motors Corporation

A. Clutch disc

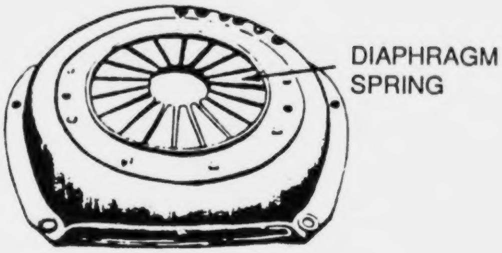
1. The center hub on the clutch disc contains splines, which engage other splines on the transmission input shaft.

2. A steel plate encircles the clutch disc's center hub. The plate is connected to the hub either directly or through a series of coil springs, which dampen the shock of clutch engagement.

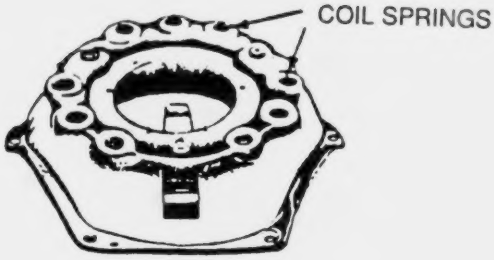

FRICTION RING
HUB FLANGE
STOP PIN
CUSHION SPRINGS
DRIVE WASHER
FACINGS
TORSIONAL COIL SPRINGS

3. Friction material, similar to brake lining, is riveted and bonded to spring-steel cushioning plates, which connect to the clutch disc. The cushioning plates provide some "give" to the friction facing of the clutch disc, thus allowing for smoother operation.

B. There are two types of clutch pressure plates: the coil spring (three finger) and the diaphragm types.



DIAPHRAGM OR BELLEVILLE SPRING

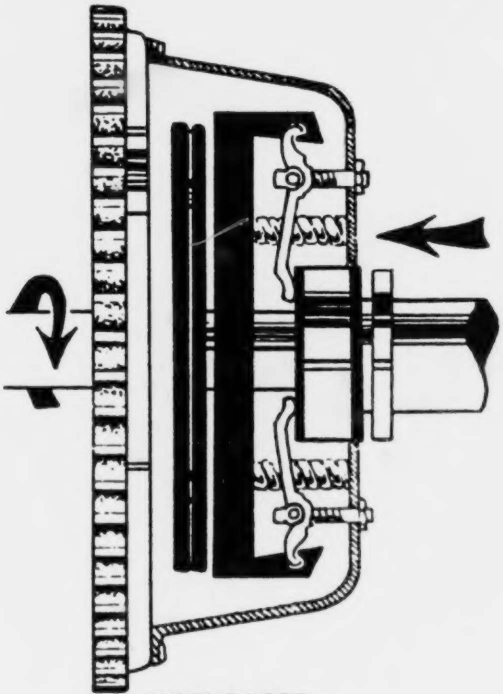


COIL SPRING

1. Coil spring (three finger) pressure plate

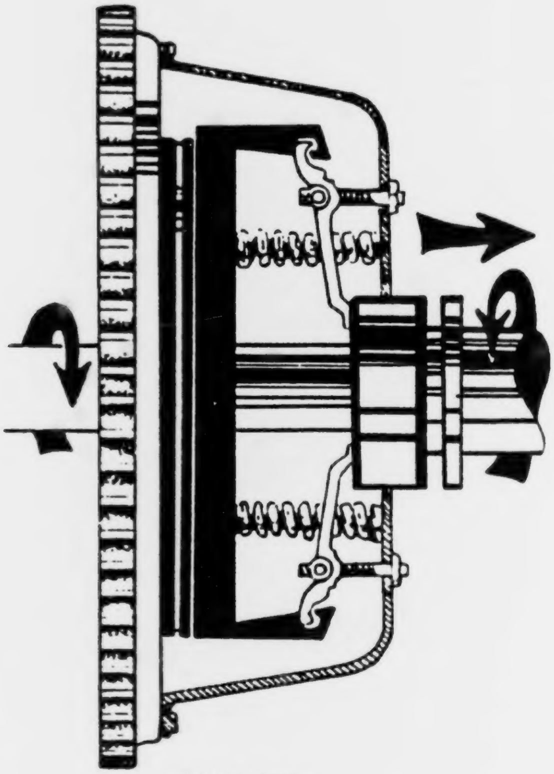
   a. In the three-finger design, pressure applied to the release fingers compresses the heavy machined plate against a series of coil springs.

   b. As the pressure plate moves away from the clutch disc, the disc is free to turn independently of the engine, thus disengaging the clutch.



DISENGAGED

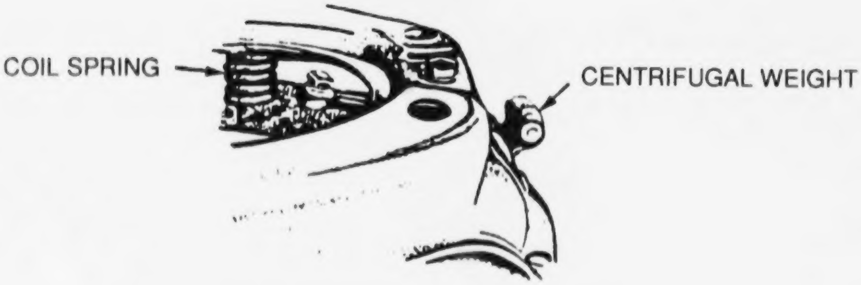
c. When pressure is removed from the release fingers, the coil springs push the pressure plate toward the clutch disc.



ENGAGED

d. As the clutch disc is compressed between the pressure plate and the flywheel, friction causes the disc to turn.

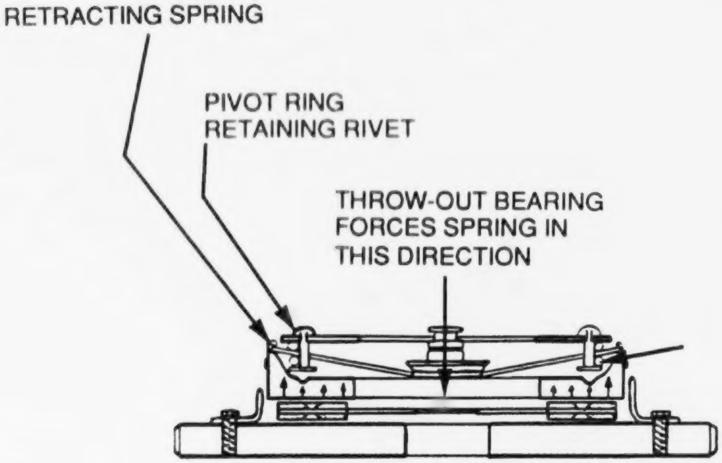
e. Some coil spring (three finger) pressure plates have weighted release fingers that apply additional pressure at high speeds. Centrifugal force (resulting from high engine rpm) activates these weighted fingers.


COIL SPRING
CENTRIFUGAL WEIGHT

CENTRIFUGAL AND COIL SPRING

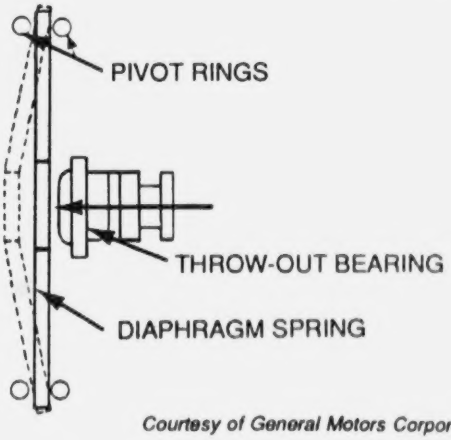
2. The diaphragm pressure plate uses a dished, spring-steel plate to apply pressure to the clutch disc.

   a. The pressure plate is divided into three portions. The center portion of the pressure plate is slotted into fingers (and referred to as the diaphragm). When pressed, the fingers cause the pressure plate surface to move away from the clutch disc. In the disengaged position, the throw-out bearing bends the clutch diaphragm fingers forward. This bending pulls the edges of the diaphragm back, thus retracting the pressure plate and leaving the clutch free to spin.


RETRACTING SPRING
PIVOT RING
RETAINING RIVET
THROW-OUT BEARING
FORCES SPRING IN
THIS DIRECTION

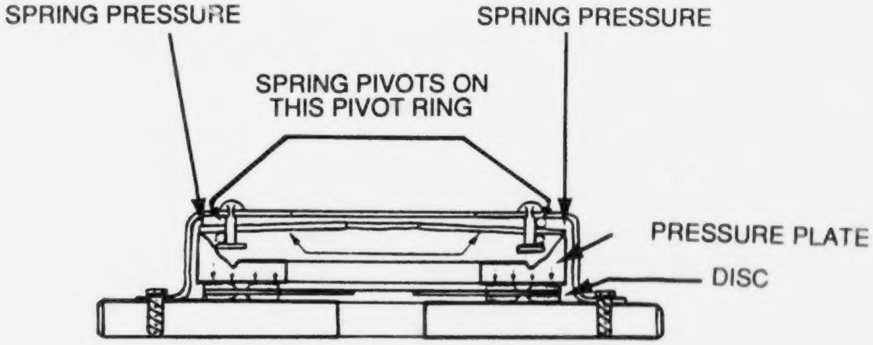
Courtesy of
Goodheart-Wilcox Co., Inc.
AUTOMECHANICS FUNDAMENTALS

b. Thus the slotted center portion of the pressure plate becomes the release mechanism for the pressure plate surface. In the below illustration, the dotted lines (which represent diaphragm spring action) show the diaphragm in the disengaged position. Notice how the outer edges move back and forth, depending on the position of the fingers.


PIVOT RINGS
THROW-OUT BEARING
DIAPHRAGM SPRING

Courtesy of General Motors Corporation

c. When pressure is removed from the release fingers, the diaphragm forces the pressure plate surface toward the clutch disc. In the engaged position, the clutch disc is pinched between the pressure plate surface and flywheel. In the following illustration, notice the spring pressure produced by the diaphragm at its outer edge.


SPRING PRESSURE
SPRING PRESSURE
SPRING PIVOTS ON THIS PIVOT RING
PRESSURE PLATE
DISC

C. Throw-out bearing and fork

1. A bearing is required to push on the clutch release fingers as they spin with the pressure plate.

2. In most vehicles, clutch linkage systems do not allow the throw-out bearing to push against the release fingers while the clutch is engaged. In these vehicles, the throw-out bearing only spins during clutch disengagement (when the clutch pedal is depressed).

3. The release fork straddles a groove in the throw-out bearing and pivots on a ball stud in the bellhousing. The release fork's lever action slides the throw-out bearing on the input shaft collar.

4. The end of the release fork protrudes from the bellhousing where the fork connects to the clutch linkage. The hole in the bellhousing is sealed with a rubber boot or stamped steel plate, which keeps dirt, water, and oil out of the clutch assembly.

D. Mechanical clutch linkage

1. The mechanical clutch linkage consists of the cross shaft assembly, a pedal rod, and a fork rod.

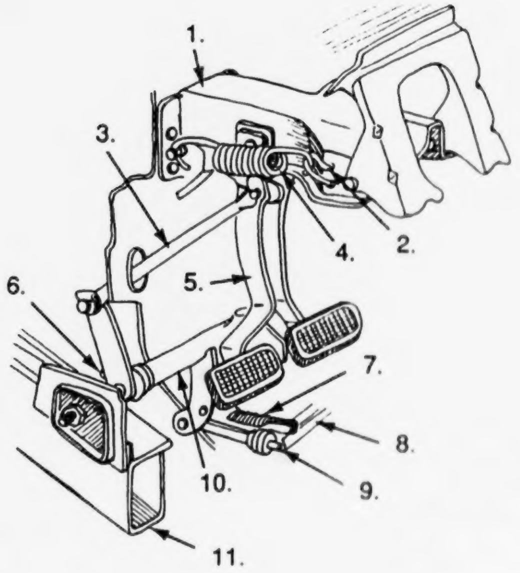
2. When the clutch pedal is depressed, the pedal rod (connected to the pedal arm) is pushed through a rubber grommet in the vehicle's fire wall.

3. The pedal rod is connected to the clutch cross shaft assembly, which pivots on ball studs in the engine block and frame.

4. The cross shaft assembly reverses the motion of the clutch linkage and pushes the fork rod against the release fork to actuate the throw-out bearing.

5. A spring is usually used to hold the fork rod in contact with the release fork.

6. When the clutch pedal is released, a return spring on the release fork sends the fork, linkage, and pedal to their original positions (clutch disengaged).



1. CLUTCH AND BRAKE PEDAL BRACKET
2. HOOK
3. PEDAL ROD
4. OVERCENTER SPRING
5. CLUTCH PEDAL
6. HOOK
7. RETURN SPRING (6 CYL. SHOWN)
8. RELEASE FORK
9. FORK ROD
10. TORQUE SHAFT ASSEMBLY
11. FRAME SIDE RAIL

Courtesy of
Goodheart-Wilcox Co., Inc.
AUTOMECHANICS FUNDAMENTALS

E. Cable clutch linkage

1. The cable clutch linkage uses a wire-wound cable to actuate the release fork.

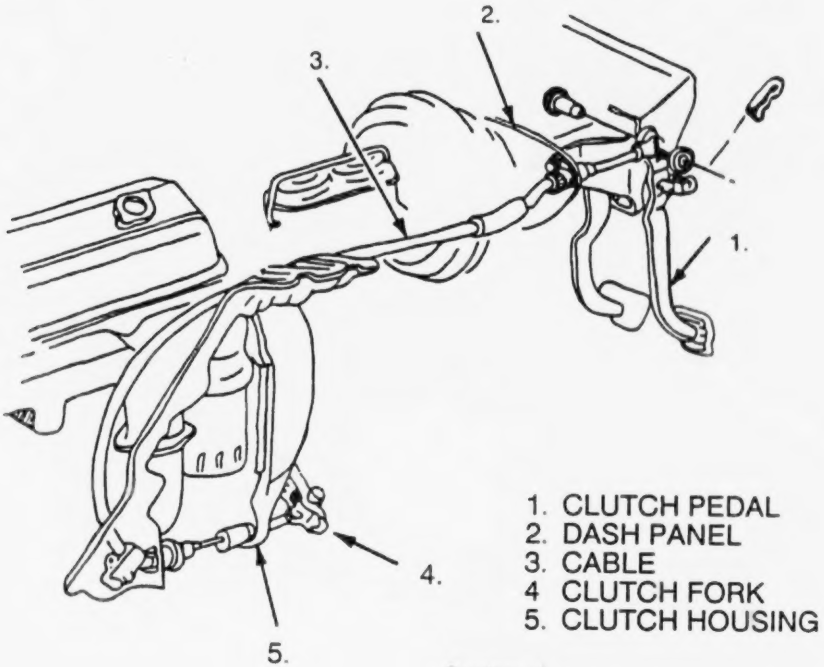
2. When the clutch pedal is depressed, the cable is pulled by the pedal arm.

3. The cable runs through the vehicle fire wall down a bracket near the release fork.

4. The cable core connects with the release fork and pulls on the fork.

5. The release fork pivots on a ball stud on the opposite side of the bellhousing so that the throw-out bearing is pressed against the release fingers.

6. When the clutch pedal is released, a return spring on the throw-out fork returns the fork, cable, and pedal to the original position (clutch engaged).



Courtesy of
Goodheart-Wilcox Co., Inc.
AUTOMECHANICS FUNDAMENTALS

F. Hydraulic clutch linkage

1. The hydraulic clutch linkage consists of a clutch master cylinder, a fluid line, and a clutch slave cylinder.

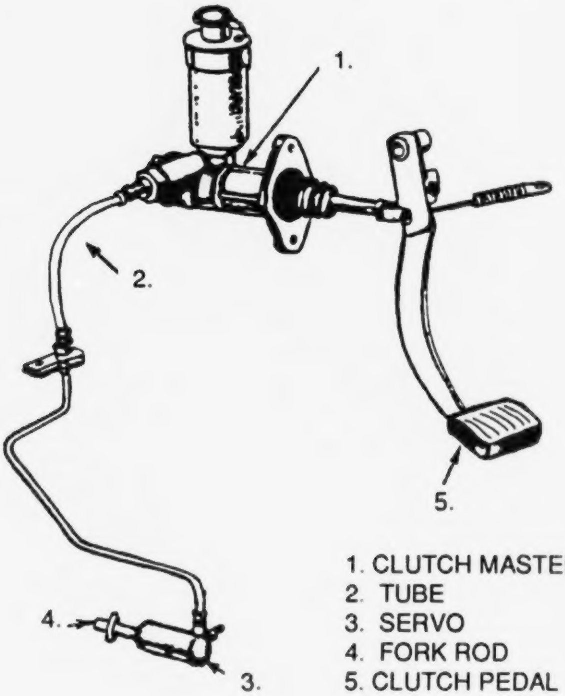
2. When the clutch pedal is depressed, a stiff steel rod connected to the pedal arm is pushed through a rubber grommet in the vehicle's fire wall.

3. This rod connects to the clutch master cylinder.

4. A fluid line brings the pressurized fluid to the clutch slave cylinder.

5. The slave cylinder moves outward, forcing a stiff steel rod against the clutch release fork.

6. When the pedal is released, return springs at the release fork and inside the master cylinder return the linkage to its original position.



1. CLUTCH MASTER CYLINDER
2. TUBE
3. SERVO
4. FORK ROD
5. CLUTCH PEDAL

G. Clutch pedal

1. Many clutch pedals use an over-center spring to improve clutch pedal action. The over-center spring, found near the top of the clutch pedal arm, is positioned so that it assists in holding up the pedal (when the pedal is up). When the pedal is depressed, the over-center spring pulls at a different angle to help push the pedal down.

2. Some cars have a self-adjusting mechanism built into the back of the clutch pedal arm. The mechanism consists of a toothed gear or block and spring that rotates the ratchet mechanism to take up looseness in cable clutch linkages. The self-adjusting spring keeps the throw-out bearing in light but constant contact with the release fingers.

MODULE: MANUAL DRIVE TRAIN AND AXLES

CLUTCH ASSEMBLY COMPONENTS AND THEIR OPERATION

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Explain why a clutch pedal should have the correct amount of free travel.

2. Explain the function of torsional coil springs in a clutch disc.

3. List four methods that are used to rate pressure plates.

MODULE: MANUAL DRIVE TRAIN AND AXLES

CLUTCH ASSEMBLY COMPONENTS AND THEIR OPERATION

(ANSWER SHEET)

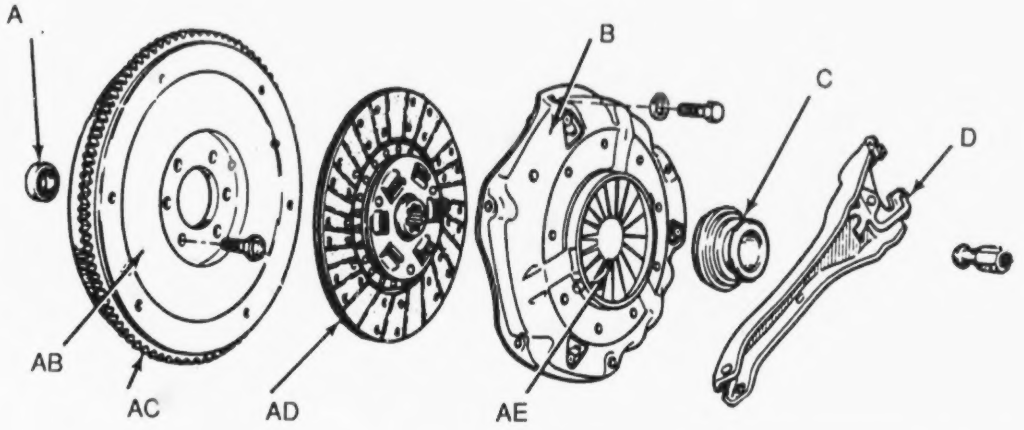
1. The correct clutch pedal free travel ensures that the clutch will not slip when engaged and that the clutch does release when disengaged. Also, if the clutch does not have any free travel, the pilot bearing may spin continuously and prematurely fail.
2. The torsional coil springs dampen the shock of clutch engagement.
3. Vehicle manufacturer, diameter, design, amount of force that the pressure plate applies to the clutch disc

MODULE; MANUAL DRIVE TRAIN AND AXLES

UNIT IV: COMPONENTS OF THE CLUTCH ASSEMBLY AND HOW THEY OPERATE

UNIT IV TEST

SECTION A. Identify the parts of the clutch assembly shown in the below illustration by matching the letter(s) of the part with the name of the part.



Courtesy of General Motors Corporation

____ 1. Release springs

____ 2. Throw-out bearing

____ 3. Pilot bearing

____ 4. Fork ball

____ 5. Clutch cover and pressure plate

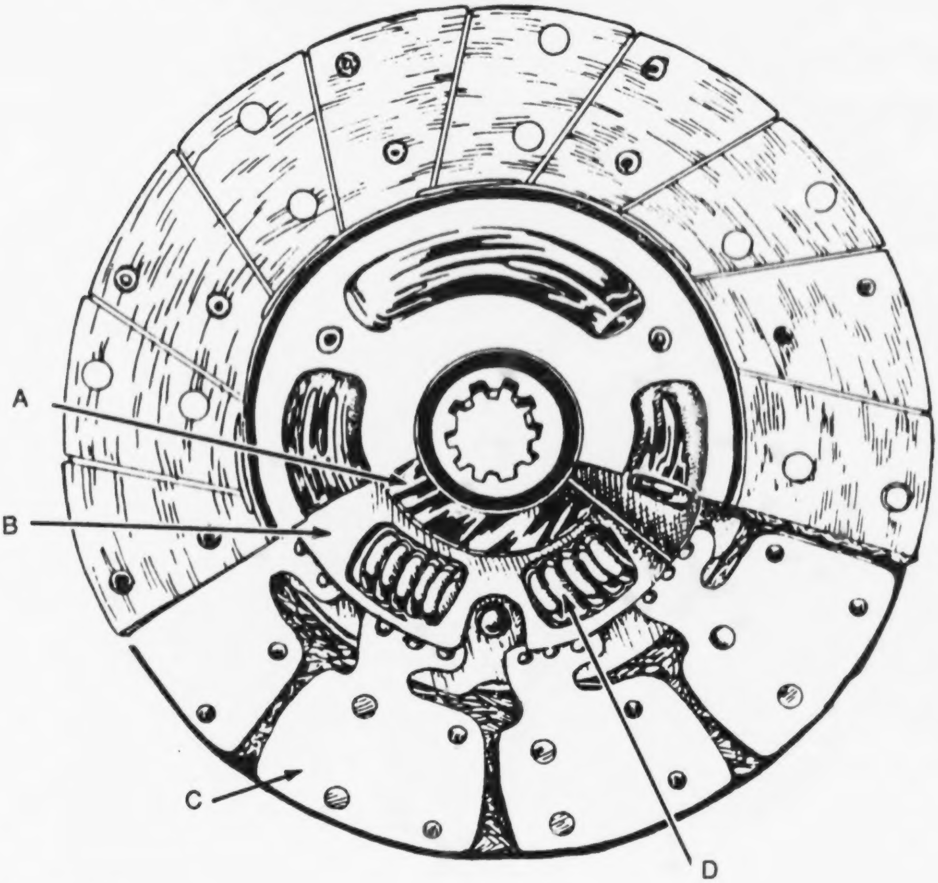
____ 6. Flywheel

____ 7. Ring gear

____ 8. Release fork

____ 9. Clutch disk

SECTION B. Identify the parts of the clutch assembly shown in the below illustration by matching the letter of the part with the name of the part.



____ 10. Hub flange

____ 11. Torsional coil springs

____ 12. Friction ring

____ 13. Cushing springs

SECTION C. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 14. The clutch diaphragm operates the throw-out bearing by pivoting on a ball in the bellhousing.

____ 15. Clutch pedal free travel is the distance that the clutch pedal must be depressed before the throw-out bearing begins to contact the clutch release fingers on the pressure plate.

____ 16. The function of the clutch throw-out fork is to put tension on the pressure plate.

____ 17. In the multiple disc clutch, all discs are driving discs.

____ 18. In the clutch assembly, the throw-out bearing is operated by the throw-out fork.

____ 19. The clutch pressure plate has a rough texture, which creates a maximum amount of friction when it contacts the clutch disc.

____ 20. Clutch release fingers pull the clutch pressure plate away from the disc when the clutch pedal is depressed.

____ 21. In the clutch assembly, the throw-out fork slides back and forth on the input shaft collar.

____ 22. In the clutch assembly, the throw-out bearing pivots on a ball stud in the bellhousing.

____ 23. The bellhousing covers the clutch assembly and provides a mounting surface for the transmission.

SECTION D. **Select the best answer from the five choices listed.**

____ 24. The center hub contains splines to engage those on

a. the transmission output shaft.
b. the transmission input shaft.
c. the counter shaft.
d. none of the above.
e. all of the above.

____ 25. The clutch pressure plate can be either the coil spring or

a. sheath type.
b. diaphragm type.
c. fork type.
d. bearing type.
e. shaft type.

____ 26. When the pressure plate moves away from the clutch disc, the disc is free to turn independently of the engine; therefore, the clutch is

a. engaged.
b. disengaged.
c. partly engaged.
d. partly disengaged.
e. none of the above.

____ 27. When the clutch disc is compressed between the pressure plate and the flywheel, friction causes the disc to turn. The turning of the disc also directly turns the

a. transmission input shaft.
b. transmission output shaft.
c. counter shaft.
d. counter gear.
e. reverse idler gear.

____ 28. In most vehicles, clutch linkage systems do not press the throw-out bearing against the release fingers when the

a. clutch is engaged.
b. clutch is disengaged.
c. transmission is in a forward gear.
d. transmission is in reverse.
e. transmission is in neutral.

____ 29. The mechanical clutch linkage consists of the cross shaft assembly and

a. one steel rod.
b. two steel rods.
c. three steel rods.
d. four steel rods.
e. eight steel rods.

____ 30. When the clutch pedal is depressed, a stiff steel rod, connected to the pedal arm, is pushed through a rubber grommet in

a. the bellhousing.
b. the wheel wells.
c. the floorboard.
d. the engine block.
e. none of the above.

____ 31. The cable clutch linkage uses a wire-wound cable to actuate the

a. flywheel.
b. clutch disc.
c. pilot bearing.
d. ring gear.
e. throw-out fork.

____ 32. When the clutch is depressed, the cable core is pulled by the

a. fork ball.
b. throw-out bearing.
c. flywheel.
d. rod connecter.
e. pedal arm.

____ 33. Unlike the cable clutch linkage, the hydraulic clutch linkage contains

a. a clutch master cylinder.
b. a fluid line.
c. a clutch slave cylinder.
d. all of the above.
e. none of the above.

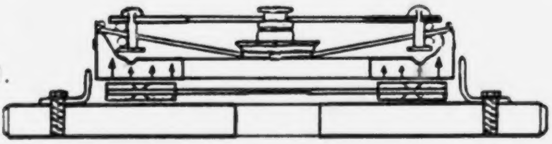
____ 34. In many clutch pedals, an over-center spring

a. prevents the cable core from snapping.
b. ensures an adequate amount of free travel in the pedal.
c. assists in holding the pedal up and pushing it down.
d. allows for adjustment of cable core tension.
e. none of the above.

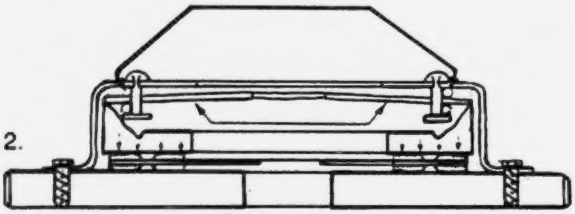
____ 35. Study the below illustrations of diaphragm-spring clutches and decide which of the below statements is true.

a. In diaphragm-spring clutch #1, the disc is pinched between the pressure plate and flywheel.
b. In diaphragm spring clutch #2, the throw-out bearing has bent the clutch diaphragm fingers inward.
c. In diaphragm-spring clutch #1, the clutch disc is free.
d. In diaphragm-spring clutch #1, the pressure plate is retracted.
e. All of the above statements are correct.

1.



2.



Courtesy of
Goodheart-Wilcox Co., Inc.
AUTOMECHANICS FUNDAMENTALS

(NOTE: The student must obtain a minimum score of _____ on the Unit IV Test in order to receive an evaluation for Competencies Z1 and Z2.)

ANSWERS TO UNIT IV TEST

1. ae
2. c
3. a
4. e
5. b
6. ab
7. ac
8. d
9. ad
10. b
11. d
12. a
13. c
14. f
15. t
16. f
17. f
18. t
19. f
20. t
21. f
22. f
23. t
24. b
25. b
26. b
27. a
28. a
29. b
30. d
31. e
32. d
33. d
34. c
35. d

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair clutch assemblies. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify problems that do not require removal of the clutch assembly and the procedures for solving these problems (Competencies Z1 and Z2, Parts I and II of the Unit V Test).

II. Identify problems that can be corrected only by removing the clutch assembly and the procedures for solving these problems (Competencies Z1 and Z2, Parts I and II of the Unit V Test).

III. Demonstrate the ability to:

   a. Diagnose, performance test, and determine needed repairs for a clutch assembly (Competency Z1, JS1-L1-UV).

Lesson 2.

I. Identify safety procedures for removing and replacing clutch assemblies (Competencies Z1 and Z2, Parts I and II of the Unit V Test).

II. Identify the procedure for removing clutch assemblies from rear-wheel-drive vehicles (Competency Z2, Part II of the Unit V Test).

III. Identify the procedure for cleaning and inspecting clutch components (Competency Z2, Part II of the Unit V Test).

IV. Identify the procedure for replacing clutch assemblies (Competency Z2, Part II of the Unit V Test).

V. Identify the procedure for performance testing clutch assemblies (Competency Z1, Part I of the Unit V Test).

VI. Demonstrate the ability to:

   a. Service the clutch assembly (Competencies Z1 and Z2, JS1-L2-UV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks C001-C007. The job sheets can be adapted to cover ASE tasks C008-C010.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR

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      JS1-L2-UV: Servicing a Clutch

E. Unit test

F. Answers to unit test

REFERENCES

Crouse, William H. Automotive Mechanics. 8th ed. New York: McGraw-Hill Book Company, 1980.

Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR

LESSON 1: CLUTCH PROBLEM DIAGNOSIS

I. Problems not requiring clutch removal

A. Clutch drag means that the clutch remains fully or partially engaged even though the clutch pedal is depressed to the floor. Clutch drag causes grinding (gear clash) on gear engagement. Listed below are possible causes of clutch drag, all of which can be corrected without removing the clutch assembly from the vehicle.

1. Excessive (more than 1 inch) pedal free travel (can be corrected by adjusting clutch linkage)

2. Worn clutch linkage (can be corrected by replacing worn parts and adjusting linkage)

3. Bent clutch shaft (can be corrected by replacing and adjusting shaft)

4. Transmission not aligned with bellhousing (can be corrected by tightening loose bolts to specifications)

5. Loose bellhousing (can be corrected by tightening loose bolts to specifications)

6. Engine misaligned due to broken or loose mounts (can be corrected by replacing or tightening mounts as required)

B. A linkage problem can cause a clutch disc to slip excessively upon engagement. The driver may complain of engine over-revving during acceleration, during shifting, or while the vehicle is travelling at high cruising speeds. The driver may also notice the smell of burning clutch facing. Listed below are possible causes of disc slippage, all of which can be corrected without removing the clutch assembly from the vehicle.

1. Driver resting his or her foot on clutch pedal

   (NOTE: If the technician is unable to duplicate the clutch slippage during a test drive, he or she should observe the driving technique of the vehicle's owner.)

2. Binding or sticking clutch pedal or linkage (can be corrected by lubricating linkage, rechecking for binding, and replacing linkage components as required)

3. Inadequate clutch pedal free travel (can be corrected by adjusting clutch linkage)

   (NOTE: One inch is usually an adequate amount of clutch pedal free travel.)

C. When the driver releases the clutch pedal, the vehicle should accelerate smoothly. If the clutch grabs when released, the vehicle will lurch. The clutch linkage should be checked for mid-travel binding. Before removing the clutch assembly, the technician should try lubricating the linkage and inspecting for worn parts.

D. A rapid gripping and then slipping of the clutch is called clutch chatter. Clutch chatter causes the vehicle to shudder when accelerating from a stop. Before removing the clutch assembly, the technician should check for a slight binding of the linkage upon clutch engagement. The technician should then lubricate the linkage and recheck for binding.

E. Squeaks or creaking sounds during pedal operation usually indicate inadequate lubrication.

II. Clutch problems requiring clutch removal

A. If the in-vehicle service procedures did not correct clutch drag, the condition may be due to the problems listed below. Correction of these problems will require removal of all or part of the clutch assembly.

1. Release levers out of adjustment on oil spring-type pressure plates (can be corrected by adjusting to factory specifications)

2. Warped clutch disc (can be corrected by replacing disc and other clutch components as required)

3. Broken clutch facing (can be corrected by replacing the disc and other clutch components as required)

4. Bent clutch shaft (input shaft) (can be corrected by replacing clutch shaft)

5. Worn clutch shaft (input shaft) bearings (can be corrected by replacing bearings as required)

6. Transmission out of alignment with bellhousing (can be corrected by tightening any loose bolts or repairing any bellhousing warping)

7. Worn clutch release fork or worn ball pivot (can be corrected by replacing components as required)

B. If clutch slippage is due to any of the problems listed below, the procedures listed above under item A will not be effective. Repair of the below problems will also require removal of all or part of the clutch assembly.

1. Binding of the clutch disc center hub on the transmission input shaft (can be corrected by removing any corrosion and burrs)

   (NOTE: If binding occurs after removal of corrosion or burrs, replace disc or clutch shaft as required.)

2. Throw-out bearing (release bearing) sticks on clutch shaft (input shaft) collar (can be corrected by removing any corrosion and burrs and applying a thin coat of lubricant)

(NOTE: If sticking occurs after removal of burrs and corrosion, replace throw-out bearing or clutch shaft collar as required.)

3. Worn clutch disc facing (can be corrected by replacing disc and other clutch components as required)

4. Pressure plate release fingers out of adjustment (can be corrected by adjusting to factory specifications)

5. Weak or broken pressure plate springs (can be corrected by replacing components as required)

6. Grease or oil on clutch assembly (can be corrected by repairing the cause of the oil leakage, cleaning oil off clutch assembly, and replacing disc and other clutch components as required)

C. If clutch grabbing is due to any of the problems listed below, the procedures listed above under items A and B will not be effective. Repair of the below problems will also require removal of all or part of the clutch assembly.

   1. Crushed cushioning plates under the facing of the clutch disc (can be corrected by replacing clutch disc and other clutch components as required)

   2. Wrong type of clutch facing (can be corrected by replacing clutch disc and other clutch components as required)

   3. Grease or oil on clutch assembly (can be corrected by repairing any oil leaks, cleaning oil off clutch assembly, and replacing discs and other clutch components as required)

D. If clutch chatter is due to any of the problems listed below, the procedures listed above under items A, B, and C will not be effective. Repair of the below problems will also require removal of all or part of the clutch assembly.

   1. Burned grease or oil on clutch assembly (can be corrected by cleaning oil off clutch assembly and replacing the disc and other clutch components as required)

   2. Damp or wet clutch friction surfaces (can be corrected by determining and repairing the cause of wetness and by replacing the disc and other clutch components as required)

   3. Warped or weak pressure plate (can be corrected by repairing pressure plate and other clutch components as required)

E. Clutch pedal pulsation (while pedal is under slight pressure during engine operation) is evidence of one of the following problems.

   1. Bent clutch shaft (input shaft) (A bent clutch shaft may cause the clutch shaft collar to move, thus moving the throw-out bearing. The movement is transferred to the clutch pedal through the linkage. Correct the problem by replacing the clutch shaft and other components as required.)

2. Pressure plate release fingers bent or improperly adjusted (problem can be corrected by adjusting or replacing the pressure plate and other clutch components as required)

F. A grinding sound that can be heard and felt in the clutch pedal while it is depressed is usually caused by a defective throw-out (release) bearing. If the throw-out bearing is the cause, the noise will stop when the pedal is released. Replace the throw-out bearing and other clutch components as required.

JS1-L1-UV

MODULE: MANUAL DRIVE TRAIN AND AXLES

DIAGNOSING, PERFORMANCE TESTING, AND DETERMINING REPAIRS FOR A CLUTCH ASSEMBLY

Equipment:

Hand tools
Hoist
Service light
Service manual
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, determine if the clutch linkage is properly adjusted. ___ ___ ___ ___

   a. Check the clutch pedal free travel. (More than 1 inch of free travel is considered excessive.)

      OK ___ NOT OK ___

   b. Does the clutch assembly have any of the following problems?

      Worn linkage
      Bent linkage
      Defective clutch cable
      Defective hydraulic system
      Loose transmission bolts
      Loose ball housing bolts
      Binding or sticking clutch pedal

      Yes ___ No ___

   c. If the clutch assembly exhibits any of the problems listed under item b above, list steps(s) to correct these problems.

3. Following the procedure outlined below, performance test a vehicle equipped with a clutch. — — — —

   a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, grabbing, slipping or other unusual activity.

   b. According to this test, is the clutch operating properly?

      Yes ____ No ____

   c. If no, explain steps that should be taken to correct the situation.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Z1. Final evaluation for Z1 will be made at the end of JS1-L2-UV.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR

LESSON 2: CLUTCH ASSEMBLY REPAIR

I. Safety in the removal of clutch assemblies

A. The technician must work underneath the vehicle in order to remove the clutch assembly. The vehicle must, therefore, be properly supported either on jackstands or a hydraulic lift rack. Refer to manufacturer's recommendations for the proper location to place the jackstands when raising the vehicle.

B. Falling debris from the underside of the vehicle presents a significant hazard. The technician must wear safety goggles or glasses while removing the clutch assembly.

C. Since the transmission must be removed to gain access to the clutch assembly, consideration must be given to the weight of the transmission and the sharp edges on the transmission housing. The technician should wear gloves and use a transmission jack.

D. Because clutch disc friction material is similar to brake shoe lining, it may contain asbestos, a cancer-causing substance. The friction material, in the form of dust, will collect in the bellhousing and on clutch components. This dust must never be inhaled or blown into the shop environment with compressed air. Consult the instructor for information on how to deal with this hazard.

(**CAUTION**: The clutch disc friction material often contains metallic slivers, which may cut the technician or lodge in his or her skin. The technician should wear protective gloves when handling the clutch disc and should never run his or her fingers over the disc edge.)

E. Never drop clutch components or the engine flywheel; these components are easily damaged.

F. Many clutch components are held in place with bolts, which are specially designed to withstand great pressure and tension. Be sure to collect all parts (including bolts) in boxes or bags.

(**CAUTION**: Do not replace clutch assembly bolts with bolts that are not factory designed. Regular bolts may not be strong enough to maintain the alignment and balance required of clutch assembly components.)

II. Procedure for removing the clutch assembly (rear drive vehicles only)

A. Remove negative battery cable. Place the vehicle securely on safety stands or lift with hoist.

B. Drain the lubricant from the transmission (if possible).

C. Remove the drive shaft using the below procedure.

1. Remove the U-bolts or straps.

2. Pry the drive shaft forward so it separates from the differential.

3. Wrap the rear U-joint with tape.

4. Slip the drive shaft out of the transmission.

D. Disconnect the shift linkage, speedometer cable, and any wire connectors from the transmission.

E. Plug lubricant leakage from transmission extension housing with an old drive shaft yoke or rag.

F. Support engine and remove transmission mount to crossmember bolts. Remove parking brake cable if necessary and remove crossmember bolts and crossmember.

G. Remove transmission to bellhousing upper bolts and replace with guide studs.

H. Remove transmission to the lower bolts of the bellhousing and carefully remove the transmission. (Use a transmission jack if necessary.)

I. Disconnect clutch linkage and cross shaft (if used).

J. Remove the throw-out bearing, if possible.

K. Remove bellhousing to engine bolts, and then remove bellhousing and release fork assembly.

(NOTE: The dust in the bellhousing may contain asbestos, a cancer-causing substance. The dust must not be inhaled or blown into the shop environment with compressed air.)

L. To hold clutch disc in position, install clutch alignment tool or dummy clutch shaft (input shaft).

M. Mark the position of the pressure plate on the flywheel.

N. Remove clutch pressure plate cover bolts and remove pressure plate.

(**CAUTION**: Using a star pattern, unscrew the pressure plate bolts one turn at a time until all pressure on the clutch disc has been released. Unscrewing the bolts in this manner prevents damage to the pressure plate.)

O. Remove clutch alignment tool and clutch disc.

P. Consult instructor for removal of flywheel and pilot bushing.

III. Clutch component cleaning and inspection

(NOTE: When cleaning clutch components, wipe grease and dirt off the pilot bushing/bearing, clutch linkage, and input shaft collar. Use a suitable solvent to clean the flywheel, pressure plate, bellhousing, and release fork.)

(**CAUTION**: Do not use solvent on the clutch disc and throw-out bearing.)

(**CAUTION:** Clutch dust may contain asbestos, a cancer-causing substance. Asbestos must not be inhaled or blown into the shop environment. Consult the instructor for proper safety procedures.)

A. Inspect pilot bushing/bearing. Bushing types may be out-of-round or exhibit other signs of excessive wear. Inspect bearing types for roughness by rotating them in fingers. Replace pilot bushing/bearing if worn or damaged.

B. Inspect flywheel surface for cracks and burnt oil deposits. Place straightedge across flywheel surface and measure warpage with feeler gauge. Compare warpage with factory tolerances. Replace or resurface flywheel as indicated.

(NOTE: If unusual amounts of oil are found in the clutch assembly, inspect rear main seal and front transmission seal for leakage.)

C. Inspect transmission input shaft collar for corrosion or excessive wear. Remove corrosion with fine steel wool. Also check tightness of bolts.

(NOTE: Replace shaft collar if it is excessively worn.)

D. Inspect bellhousing for cracks. Replace bellhousing if necessary. Have surfaces milled flat if symptoms indicate transmission misalignment.

E. Inspect ball stud and release fork. Replace ball stud if worn. Inspect release fork for wear at throw-out bearing contact points, ball stud pivot point, and linkage attachment point. Replace release fork if worn or bent.

F. Inspect clutch disc for missing parts and worn friction facing (worn down to rivet heads). Check for dampness or oil contamination. Replace clutch disc as indicated.

G. Inspect pressure plate for missing parts and worn release fingers. Also inspect plate surface for heat cracks and burnt oil deposits. Resurface or replace pressure plate as indicated.

H. Inspect clutch linkage for missing or worn parts. Check hydraulic systems for leaks in the master cylinder, fluid lines, or slave cylinder. Rebuild or replace clutch cylinders as required.

I. Inspect the throw-out bearing to confirm that it rotates freely, is not excessively loose, and does not have a surface groove that contacts the pressure plate.

IV. Procedure for replacing clutch assembly

A. Apply a thin coat of grease to the clutch assembly at the points listed below.

1. Pilot bushing/bearing inner hole

2. Pilot end of transmission input shaft

3. Input shaft collar

4. Throw-out bearing inner hole and fork groove

5. Bellhousing ball stud and release fork pivot point

B. Install flywheel (if previously removed) and torque bolts to factory specifications.

C. Using a brake cleaner or other suitable solvents, remove grease from the surface of the flywheel and pressure plate.

D. Hold clutch disc in position with dummy input shaft or clutch alignment tool.

E. Install pressure plate. Tighten bolts gradually to pull pressure plate down evenly. Torque bolts to factory specification.

(NOTE: Use only bolts designed for flywheel and pressure plates.)

F. Adjust release fingers as required by manufacturer.

G. Insert throw-out bearing into clips on release fork. Snap fork into position over bellhousing ball stud.

H. Remove dummy input shaft or alignment tool and install bellhousing and throw-out assembly. Tighten bolts to specification.

I. Install guide studs in upper transmission holes on the bellhousing.

J. Insert a drive shaft yoke (if available) into the extension housing of the transmission and shift into any gear.

K. Carefully raise the transmission into position and insert input shaft through throw-out bearing. Use guide studs to align transmission, and slide transmission toward bellhousing. If input shaft splines will not engage clutch disc splines, turn the drive shaft yoke until splines engage. Slide transmission all the way in against bellhousing.

(**CAUTION**: Never draw the transmission into position with bolts. Doing so can break the transmission case ears. Failure of the transmission to seat fully may indicate misalignment of the clutch disc with the pilot bushing.)

L. Remove guide studs and install bolts. Tighten to specification.

M. Inspect condition of transmission crossmember mount. If the mount is oil-softened or broken, replace it with a new mount. Install the mount on the extension housing.

N. Install transmission crossmember and parking brake cable (if required).

O. Lower engine support until transmission rear mount rests on the crossmember. Move transmission laterally until bolts can be installed through the crossmember into the transmission mount. Tighten to specifications.

P. Install the drive shaft using the procedure outlined below.

1. Remove the yoke from the extension housing (if used).
2. Remove the tape from the rear U-joint bearing cups.
3. Apply lubricant to front drive shaft yoke.

4. Insert yoke into transmission extension housing.

5. Insert rear U-joint into differential companion flange.

6. Install U-bolts and tighten evenly.

Q. Connect speedometer, drive cable, and any wire connectors to transmission.

R. Connect and adjust clutch linkage. Refer to manual for correct procedures. Lubricate linkage as required.

S. Connect and adjust shift linkage. This procedure is found in Unit III of this module.

T. Remove side plug from transmission case and fill to within 1/4 inch from hole with correct gear lubricant. Replace plug.

U. Inspect transmission and hydraulic clutch linkages for leaks. Lower vehicle and attach negative battery cable.

V. Clutch performance testing

A. Operate clutch pedal and note any squeaks or unusual noises. Recheck free travel on clutches that do not self-adjust free travel. Proper free travel is about 1 inch.

B. After obtaining the instructor's approval, start vehicle with transmission in low gear and clutch pedal depressed to the floorboard.

C. Gradually release pedal until vehicle begins to creep. Note any unusual noises. Friction point should occur when pedal is about halfway between the floorboard and the end of its free travel.

D. Turn off engine. Shift transmission into neutral and attempt to crank starter with clutch pedal up (clutch engaged).

(NOTE: Clutch safety switch on newer vehicles should prevent cranking of starter. If starter cranks, refer to manual for repair of clutch safety circuit.)

E. Drive vehicle to verify proper clutch engagement and smoothness of clutch movement. Note any unusual sounds or vibrations.

F. Recheck free play. Also recheck clutch fluid or transmission lubricant.

(NOTE: Normal clutch operation will result in gradual wear of clutch disc facing. As the facing wears, movement of the pressure plate release fingers will reduce free travel of the clutch pedal. Clutches that are not self-adjusting will require adjustment of free travel.)

(NOTE: Fluid will occasionally have to be added to the master cylinder in hydraulic clutch assemblies.)

MODULE: MANUAL DRIVE TRAINS AND AXLES

SERVICING A CLUTCH

Equipment:

Hand tools
Hoist
Serviceable vehicle
Transmission jack
Torque wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the car securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Remove the negative battery cable before raising the vehicle.)

3. Remove the manual transmission. For the proper procedure, refer to JS1-L2-UIII or JS1-L2-UXI. ___ ___ ___ ___

4. Following the procedure outlined below, remove the clutch assembly. ___ ___ ___ ___

   a. Remove the clutch linkage.

   b. Remove the bellhousing.

   c. Mark the position of the pressure plate on the flywheel.

   d. Remove the pressure plate and clutch disc.

   e. Remove the flywheel.

5. Using the following checklist, clean and inspect clutch components. — — — —

    a. Pilot bushing OK ___ NOT OK ___

    b. Flywheel OK ___ NOT OK ___

    c. Transmission input shaft collar OK ___ NOT OK ___

    d. Bellhousing OK ___ NOT OK ___

    e. Ball stud and release fork OK ___ NOT OK ___

    f. Clutch disc OK ___ NOT OK ___

    g. Pressure plate OK ___ NOT OK ___

    h. Clutch linkage OK ___ NOT OK ___

    i. Throw-out bearing OK ___ NOT OK ___

    For each item that is not OK, explain the problem and list steps to correct the situation.

6. Following the procedure outlined below, replace the clutch assembly. — — — —

   a. Install the pilot bearing (if required).

   b. Apply a thin coat of grease to the following items:

   Pilot bearing inner hole
   Pilot end of transmission shaft
   Input shaft collar
   Throw-out bearing inner hole and fork groove

   c. Install flywheel (if previously removed) and torque bolts to factory specifications.

   d. Using a brake cleaner or other suitable solvents, remove grease from the surface of the flywheel and pressure plate.

   e. Hold clutch disc in position with dummy input shaft or clutch alignment tool.

   f. Install pressure plate. Tighten bolts gradually to pull pressure plate down evenly. Torque bolts to factory specifications.

   (NOTE: If the same pressure plate is being reinstalled, it must be located in the same position as before.)

   (NOTE: Use only bolts that are designed for flywheel and pressure plates.)

   g. Adjust release fingers as required by manufacturer.

   h. Insert throw-out bearing into clips on release fork. Snap fork into position over bellhousing ball stud.

   i. Remove dummy input shaft or alignment tool and install bellhousing and throw-out assembly. Tighten bolts to specification.

   j. Install guide studs in upper transmission holes on the bellhousing.

   k. Adjust the clutch pedal free travel.

7. Reinstall and adjust the manual transmission. For the proper procedure, refer to JS2-L3-UIII or JS1-L3-UXI. — — — —

8. Using the procedure outlined below, performance test the clutch. — — — —

   a. Operate clutch pedal and note any squeaks or unusual noises. Recheck clutches that are not self-adjusting for proper free travel. (Proper free travel is approximately 1 inch.)

b. After obtaining instructor's approval, start vehicle while transmission is in low gear and clutch pedal is depressed to the floorboard.

c. Gradually release pedal until vehicle begins to creep. Note any unusual noises. Friction point should occur when pedal is approximately halfway between the floorboard and the end of clutch pedal travel.

d. Turn off engine. Shift transmission into neutral and attempt to crank starter with clutch pedal up (clutch engaged).

e. Drive vehicle to verify clutch smoothness and engagement. Note any unusual sounds or vibrations.

f. Recheck free play. Also recheck clutch fluid or transmission lubricant.

(NOTE: Normal clutch operation will result in gradual wear of clutch disc facing. As the facing wears, movement of the pressure plate release fingers will reduce free travel of the clutch pedal. Clutches that are not self-adjusting will require adjustment of free travel.)

(NOTE: Fluid will occasionally have to be added to the master cylinder in hydraulic clutch assemblies.)

g. Record results of clutch performance test.

Average of above evaluations* — — — —

(*This average is partial evaluation for Competency Z1. This average is also a partial evaluation for Competency Z2. Final evaluation for Z1 will be made at the end of this job sheet. Final evaluation for Z2 will be made at the end of JS2-L2-UXI.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Z1 by averaging the final evaluation of JS1-L1-UV and JS1-L2-UV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UV	___	___	___	___
JS1-L2-UV	___	___	___	___
Final evaluation for Competency Z1	___	___	___	___

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT V: CLUTCH ASSEMBLY, DIAGNOSIS, AND REPAIR

UNIT V TEST

PART I. DIAGNOSING AND PERFORMANCE TESTING THE CLUTCH ASSEMBLY

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. If the clutch grabs, the clutch linkage should be checked for mid-travel binding.

____ 2. Squeaks and creaking sounds from the clutch pedal are called clutch chatter.

____ 3. Clutch chatter usually indicates inadequate lubrication of clutch assembly components.

____ 4. Dust on the bellhousing or on clutch components may contain asbestos, a cancer-causing substance.

____ 5. When performance testing a clutch, the technician should release the clutch while the vehicle is in the highest gear possible in order to make sure all clutch components can withstand a significant amount of strain.

____ 6. When releasing the clutch pedal, the friction point should occur when the pedal is about halfway between the floorboard and the end of pedal free travel.

____ 7. Normal wear of the clutch disc facing will cause movement of the pressure plate release fingers which, in turn, will increase clutch pedal free travel.

____ 8. The fluid level in the master cylinder of the hydraulic clutch should remain constant unless there is a crack or hole in the cylinder.

SECTION B. **Select the best answer from the five choices listed.**

____ 9. When cleaning clutch components, use a suitable solvent to clean

a. the flywheel.
b. the clutch disc.
c. the clutch throw-out bearing.
d. none of the above.
e. all of the above.

____ 10. The technician can best inspect pilot bearings by

a. rolling them across a smooth surface.
b. examining them under a magnifying glass.
c. rolling them through a pipe or tube.
d. rotating them with his or her finger.
e. doing none of the above.

____ 11. If an unusual amount of oil is found in the clutch assembly, check for leakage in

a. the engine crank case.
b. the engine oil filter.
c. the universal joint.
d. all the above locations.
e. none of the above locations.

____ 12. When inspecting the clutch flywheel, place a straightedge across the flywheel surface and measure warpage with

a. calipers.
b. a level.
c. a protractor.
d. a square.
e. none of the above.

____ 13. The technician should remove corrosion from the transmission input shaft collar with

a. a coarse file.
b. fine steel wool.
c. hydrochloric acid.
d. sulfuric acid.
e. lactic acid.

____ 14. The technician should inspect the release fork at

a. throw-out bearing contact points.
b. ball stud pivot points.
c. linkage attachment points.
d. none of the above locations.
e. all of the above locations.

SECTION C. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 15. Technician I says that a worn clutch linkage can be corrected by replacing worn parts and adjusting the linkage.

Technician II says that a binding or sticking clutch pedal linkage can be corrected by tightening bellhousing bolts.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 16. Technician I says that clutch drag can be caused by a misaligned engine.

Technician II says that clutch linkage problems can cause a clutch disc to slip even if the disc is in good condition.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. Technician I says that a warped clutch disc should be corrected by milling the disc's surface.

Technician II says that clutch slippage can be corrected by thoroughly greasing all clutch assembly components.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 18. Technician I says that, if pressure plate fingers are out of adjustment, they should be replaced.

Technician II says that crushed cushioning plates can cause the clutch to grab.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 19. Technician I says that a grinding sound heard while the clutch pedal is depressed is usually caused by a defective pedal push rod.

Technician II says that a warped or weak pressure plate can cause clutch chatter.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 20. Technician I says that a bent clutch shaft can cause the clutch pedal (while under slight pressure) to pulsate with every revolution of the engine.

Technician II says that the wrong type of clutch facing can cause a clutch to grab.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit V Test in order to receive an evaluation for Competency Z1.)

PART II. REPLACING CLUTCH ASSEMBLY

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 21. Before installing the clutch assembly, the technician should apply a thin coat of grease to the flywheel.

____ 22. When installing the clutch assembly, the technician should hold the clutch disc in position with a dummy input shaft or clutch alignment tool.

____ 23. The clutch pressure plate is held in place with steel clamps.

____ 24. If, during transmission installation, the input shaft splines will not engage the clutch disc splines, the technician should turn the drive shaft yoke until splines engage.

____ 25. Failure of the transmission to seat fully during installation may indicate misalignment of the clutch disc with the pilot bushing.

____ 26. When installing the drive shaft, the technician should wipe any grease, oil, or other lubricant from the front drive shaft yoke.

____ 27. After lowering engine support until transmission rear mount rests on the crossmember, the technician should move the transmission latterly until bolts can be installed through the crossmember into the transmission mount.

____ 28. After installing a hydraulic clutch, slow but steady leakage from the master cylinder can be expected.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit V Test in order to receive an evaluation for Competency Z2.)

ANSWERS TO UNIT V TEST

1. t
2. f
3. f
4. t
5. f
6. t
7. f
8. f
9. b
10. d
11. e
12. e
13. b
14. e
15. a
16. c
17. d
18. c
19. b
20. c
21. f
22. t
23. f
24. t
25. t
26. f
27. t
28. f

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair drive shaft assemblies. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with drive shaft diagnosis and repair (Competencies Bb1 and Bb3, Unit VI Test).

II. Identify safety procedures for diagnosing, removing, and replacing drive shaft components (Competencies Bb1 and Bb3, Unit VI Test).

III. Identify procedures for diagnosing drive shafts and universal joints on rear-wheel-drive vehicles (Competency Bb1, Unit VI Test).

IV. Identify procedures for removing a one-piece drive shaft assembly (Competency Bb3, Unit VI Test).

V. Identify procedures for removing a two-piece drive shaft assembly that has center support bearings (Competency Bb3, Unit VI Test).

VI. Identify procedures for removing a double-cardan drive shaft assembly with a rear CV joint (Competency Bb3, Unit VI Test).

Lesson 2. I. Identify components of a one-piece single-cardan shaft assembly (Competencies Bb1 and Bb3, Unit VI Test).

II. Identify components of the two-piece shaft assembly (Competencies Bb1 and Bb3, Unit VI Test).

III. Identify components of the double-cardan constant-velocity joint (Competencies Bb1 and Bb3, Unit VI Test).

IV. Identify vibration-control devices and the principles by which they work (Competencies Bb1 and Bb3, Unit VI Test).

V. Identify the principles by which the drive shaft and U-joint operate (Competencies Bb1 and Bb3, Unit VI Test).

Lesson 3. I. Identify the procedures for inspecting a drive shaft (Competency Bb3, Unit VI Test).

II. Identify the procedures for reassembling and installing drive shaft assemblies (Competency Bb3, Unit VI Test).

III. Demonstrate the ability to:

  a. Service a drive shaft (Competencies Bb1 and Bb3, JS1-L3-UVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheet in this unit covers ASE tasks C046-C048. The job sheets can be adapted to cover C049 and C050.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DRIVE SHAFT DIAGNOSIS AND REMOVAL

     a. Information outline

  2. Lesson 2: DRIVE SHAFT COMPONENTS

     a. Information outline

  3. Lesson 3: DRIVE SHAFT INSPECTION AND REPAIR

     a. Information outline

     b. Job sheets:

        JS1-L3-UVI: Servicing a Drive Shaft

E. Unit test

F. Answers to unit test

REFERENCES

Crouse, William H. Automotive Mechanics. 8th ed. New York: McGraw-Hill Book Company, 1980.

Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.

   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

LESSON 1: DRIVE SHAFT DIAGNOSIS AND REMOVAL

I. Terms and definitions

   A. Bearing cup--A steel cup containing a row of needle bearings that turn on the U-joint crosspiece trunion. When pressed or clamped into a companion yoke, the bearing cup allows the U-joint to flex.

   B. Cardan joint--A type of U-joint consisting of a crosspiece and bearing cups that join with yokes on either side.

   C. Carrier bearing--The center support bearing on a two-piece drive shaft.

   D. Constant velocity joint (CV joint)--Any type of drive shaft joint that delivers smooth turning motion, regardless of the angle at which the joint operates.

   E. Companion flange--The steel yoke that couples the rear U-joint to the differential drive pinion gear.

   F. Crosspiece (spider)--The steel center portion of the cardan universal joint. The crosspiece has four machined trunions on which the bearing cups can turn.

   G. Trunion--One of the machined journals of the U-joint crosspiece on which the bearing cups turn.

   H. Universal joint--A flexible coupling that allows a driving shaft and a driven shaft to continue operation during changes in their angles.

   I. Yoke--A flange that couples a universal joint to a shaft. The yoke holds bearing cups at opposite ends of the U-joint. The yoke is splined, bolted, or welded to the shaft.

II. Safety in drive shaft and universal joint problem diagnosis

   A. Never test drive a vehicle without the instructor's approval and supervision.

   B. Never drive a vehicle with its doors open. Never attempt to listen to sounds coming from underneath a moving vehicle.

   C. Safety considerations for running vehicle while on lift rack

      1. Never operate a vehicle on hydraulic lift rack without the approval and supervision of the instructor.

      2. Stay clear of hot exhaust components. A catalytic converter may exceed temperatures over 1000 °F.

      3. Stay clear of moving parts on vehicles. Long hair or loose clothing can become entangled in moving parts.

4. Wear protective clothing and safety goggles.

5. Make sure vehicle exhaust is ventilated outdoors.

6. Never attempt to engage cruise control while the vehicle is on a lift rack.

III. Procedures for diagnosing drive shaft and universal joint problems (rear-wheel-drive vehicles)

A. Procedure for diagnosing a clunking sound occurring upon clutch engagement

1. Inspect engine and transmission mounts for looseness.

2. Inspect differential control arms and bushings for looseness.

3. Eliminate clutch and transmission problems as the possible cause of clunking sounds.

4. With the engine off and vehicle supported on a lift rack or jackstands, grasp the drive shaft. Shake shaft up and down at each end. Any movement between yokes indicates looseness.

5. Rotate drive shaft back and forth. Any movement between yokes indicates a defective U-joint.

(NOTE: U-joint repair requires that the shaft be removed.)

B. Procedure for diagnosing clicks or squeaks that occur when backing vehicle

1. Make sure the sounds are not coming from the hub caps. Rocks or loose parts can make hub caps sound like a faulty U-joint.

2. Make sure defective wheel bearings are not the source of the noise.

3. Remove drive shaft to check for binding U-joints.

C. At times a vehicle may operate with a great deal of vibration. Though sometimes caused by tire runout or imbalance, vibration may also be due to drive shaft and U-joint problems. The vehicle should be checked as soon as the vibration occurs. The vibration may be due to one or more of the problems listed below.

1. Excessive mud or undercoating

2. Excessive imbalance due to lost balance weight

3. Drive shaft bent (excessive runout)

4. Loose rear U-bolts

5. Rear U-joint improperly seated in differential companion flange

6. Loose or tight U-joint

7. Excessive looseness at slip yoke bushing

8. Differential companion flange imbalance or runout

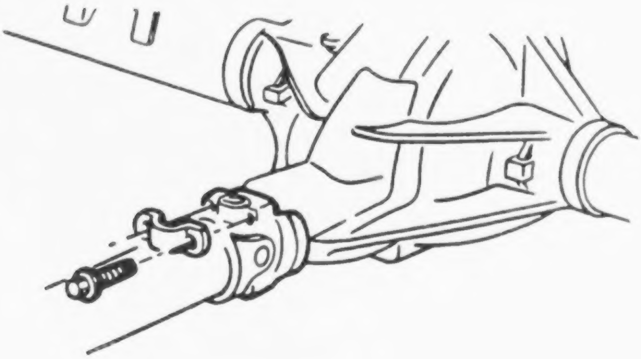
(NOTE: Vibration resulting from drive shaft or U-joint problems will increase if vehicle is under a load. These vibrations generally become noticeable when the vehicle reaches 35-45 mph. The intensity of the vibrations usually varies with changes in the vehicle's speed.)

D. Roughness at 15-25 mph under light load may be caused by excessively tight U-bolts.

E. Brief roughness upon heavy acceleration may be caused by worn double-cardan joint ball seats.

IV. Procedure for removing drive shaft assemblies (one-piece types)

A. Remove the U-bolts or straps that hold the rear U-joint to the differential companion flange.



Courtesy of General Motors Corporation

B. Move the drive shaft forward to separate the rear U-joint from the companion flange.

C. Wrap the rear U-joint bearing cups with tape to keep them from falling off the rear U-joint during removal of the drive shaft.

D. Slip the front yoke of the drive shaft out of the transmission extension housing.

E. Remove center support bolts from crossmember and slip center support and front drive shaft assembly from transmission.

V. Procedure for removing drive shaft assembly (two-piece types with center support bearing)

A. Remove the U-bolts or straps that hold the rear U-joint to the differential companion flange.

B. Pry the drive shaft forward to separate the rear U-joint from the companion flange.

C. Wrap the rear U-joint bearing cups with tape to keep them from falling off when drive shaft is removed.

D. Slip rear drive shaft from splined union at center support bearing.

E. Remove center support bolts from crossmember and slip center support and front drive shaft assembly from transmission.

VI. Procedure for removing drive shaft assembly (double-cardan rear CV joint)

A. Remove the bolts that join the differential companion flange to the rear U-joint yoke.

B. Separate the rear yoke from the companion flange with a small pry bar.

(NOTE: On some models the rear yoke can be separated from the companion flange by threading a bolt with the same thread size as the flange bolts into a specially threaded hole in the companion flange. When this bolt is tightened, it runs into an area of the rear-yoke mating surface that is not drilled, forcing the rear yoke away from the companion flange.)

C. Slide the drive shaft forward and then lower it to clear the differential.

D. Slip the drive shaft assembly from the transmission extension housing.

(NOTE: To prevent loss of transmission fluid, an old yoke or rag should be installed in place of the drive shaft yoke.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

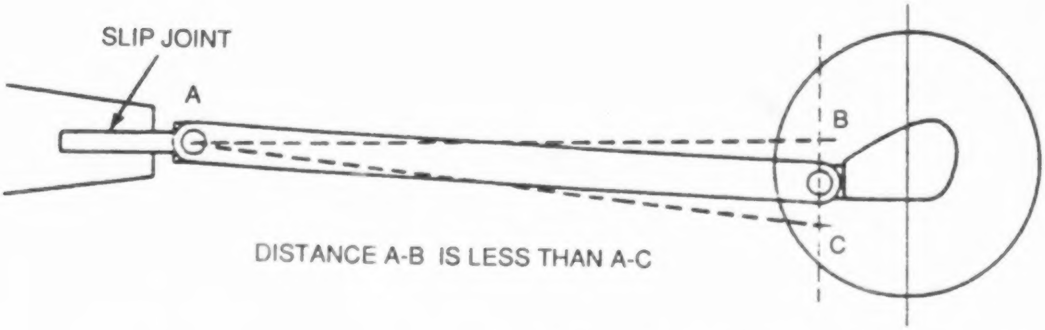
UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

LESSON 2: DRIVE SHAFT COMPONENTS

I. Components of one-piece shaft assembly (single-cardan type)

A. Slip yoke

1. Since the differential rides on a spring suspension, it will move up and down in relation to the transmission. This up and down movement requires the drive shaft to change length while operating.

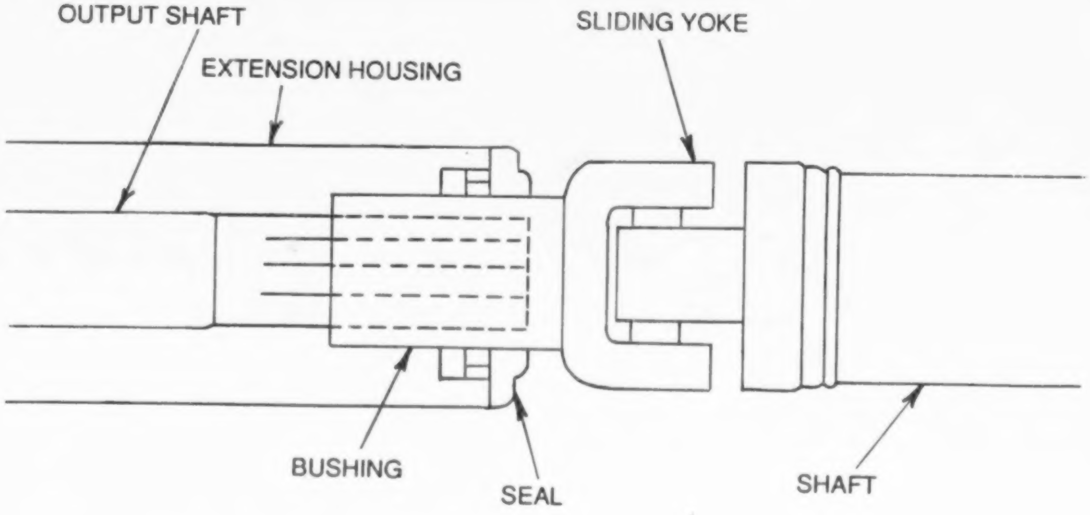


Herbert E. Ellinger, AUTOMECHANICS, 4/E, c 1988, p. 314.
Reprinted by permission of Prentice-Hall, Englewood Cliffs, NJ

2. The slip yoke can accommodate this change in length by sliding in and out of the transmission extension housing on a bushing.

3. To provide positive coupling with the transmission mainshaft (output shaft), the slip yoke contains internal splines to engage with those on the mainshaft.

4. A rubber seal prevents transmission lubricant leakage by sealing with the smooth outer surface of the slip yoke.

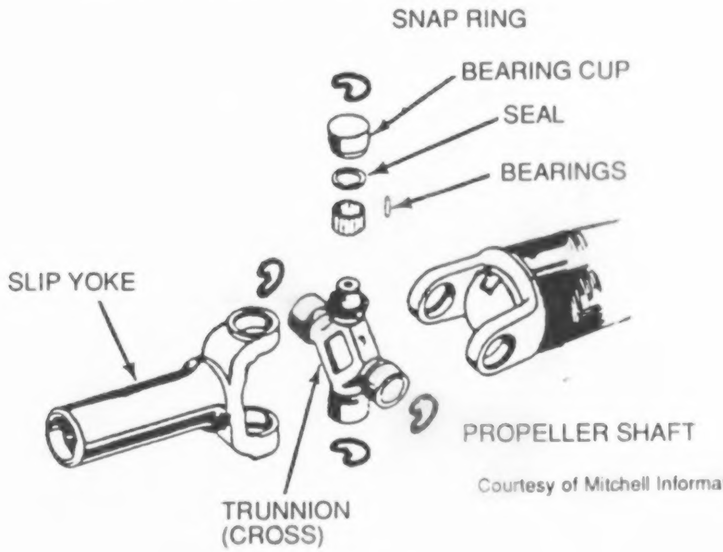

OUTPUT SHAFT
EXTENSION HOUSING
SLIDING YOKE
BUSHING
SEAL
SHAFT

B. Front universal joint (U-joint)

1. The crosspiece is the heart of the cardan U-joint. Made of hard iron or steel, the crosspiece has four precision-machined journals called trunions. The crosspiece is usually hollow so it can hold grease for the bearings. Some crosspieces have a grease fitting (zerk fitting) to allow for periodic lubrication.

2. The bearing cup assembly fits on the trunion crosspiece, allowing the cups to rotate on the trunions (also allowing for U-joint flection). The bearing cup is made of precision-machined steel with a row of needle bearings attached to its machined surface.

SINGLE CROSS AND ROLLER TYPE JOINT


SNAP RING
BEARING CUP
SEAL
BEARINGS
SLIP YOKE
PROPELLER SHAFT
TRUNNION
(CROSS)

Courtesy of Mitchell Information Services, Inc.

C. Drive shaft and yokes

1. The drive shaft is a long, hollow steel tube. The use of a hollow tube instead of a solid shaft greatly reduces the weight of the drive shaft while increasing its rigidity. To prevent "ringing," some drive shaft tubes are filled with foam.

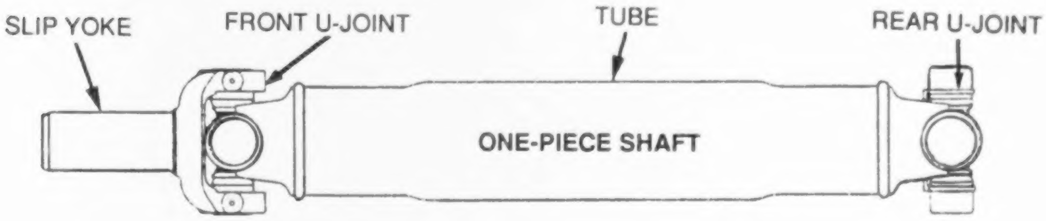
2. Steel yokes welded at each end of the drive shaft tube allow the shaft to join with the U-joints.

3. At the factory, weights are welded to the drive shaft to make it perfectly balanced.

D. Rear universal joint (U-joint)

1. Though it may be different in size, the rear U-joint has the same parts as the front U-joint on nonconstant velocity (single-cardan) drive shaft assemblies.

2. The rear U-joint attaches to the differential companion flange with U-bolts or straps.



II. Components of a two-piece shaft assembly

A. In order to reduce the height of the drive shaft tunnel in the passenger compartment while still allowing maximum differential movement, some vehicles use a two-piece drive shaft assembly that pivots at the center. This pivoting keeps the forward shaft in position. The rear shaft accommodates all differential travel. The two-piece drive shaft uses the same components as the one-piece, plus the center support bearing and slip yoke.

1. Carrier bearing and center support

a. The carrier bearing is caged and sealed. The bearing is pressed onto the machined end of the front drive shaft end

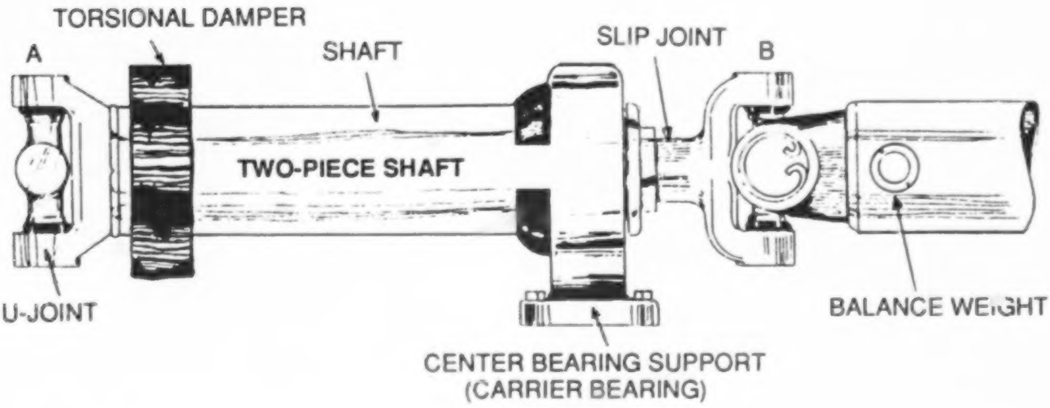
b. The carrier bearing is mounted in a large rubber bushing, which absorbs vibration.

c. The rubber bushing is held stationary by a bracket attached to the vehicle's frame or crossmember.

2. Slip yoke

   a. The rear drive shaft has a slip yoke at the front to engage splines on the rear of the front drive shaft.

   b. The slip yoke can slide as necessary to accommodate differential movement.


TORSIONAL DAMPER
A
SHAFT
SLIP JOINT
B
TWO-PIECE SHAFT
U-JOINT
BALANCE WEIGHT
CENTER BEARING SUPPORT
(CARRIER BEARING)

   c. A torsional vibration damper is a heavy wheel placed on the yoke or drive shaft. The damper uses inertia to reduce torsional vibrations.

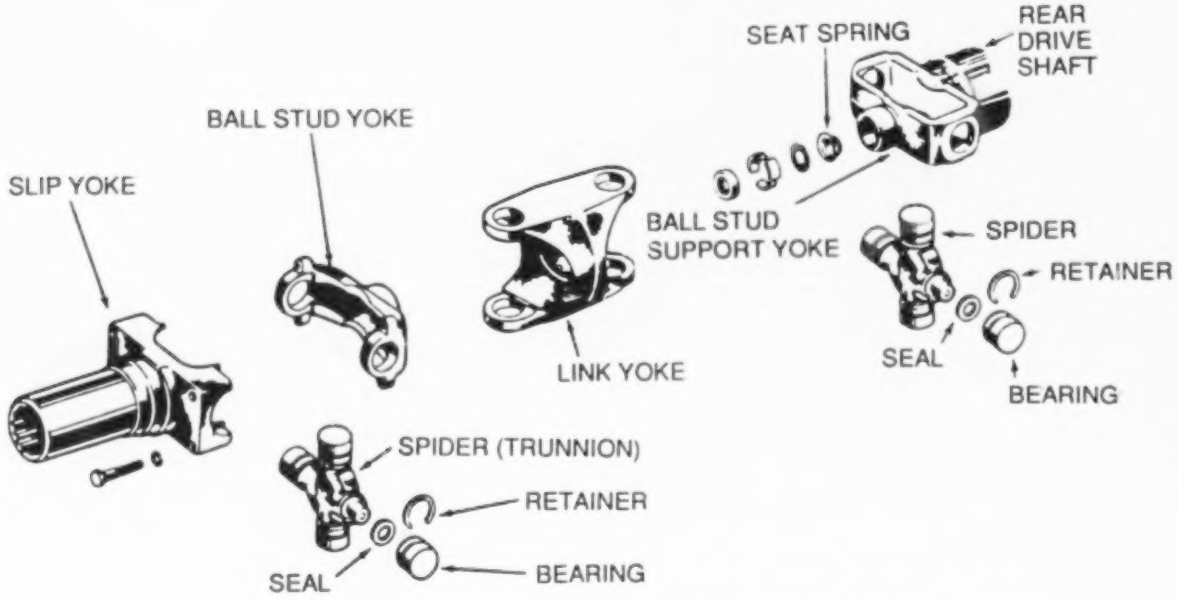
III. Components of the double-cardan constant-velocity joint

(NOTE: Some vehicles use a double-cardan constant-velocity joint at one or both ends of the drive shaft assembly.)

A. Inside the constant velocity joint, a ball stud assembly is attached to the end of the ball stud yoke. This assembly maintains alignment with the rear yoke.

B. The link yoke is a major component of the constant velocity joint. The yoke is made of cast iron or steel and is machined to join a cardan U-joint at each end.

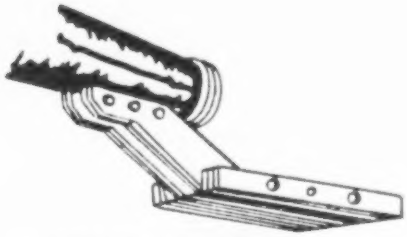
C. The ball stud support yoke is joined to the rear U-joint. The ball stud support contains a seat and spring, which mate with the stud on the other yoke to maintain alignment.


SEAT SPRING
REAR DRIVE SHAFT
BALL STUD YOKE
SLIP YOKE
BALL STUD SUPPORT YOKE
SPIDER
RETAINER
SEAL
BEARING
LINK YOKE
SPIDER (TRUNNION)
RETAINER
SEAL
BEARING

D. Constant velocity U-joints maintain a constant turning speed and thus reduce torsional vibrations.

IV. Vibration control devices

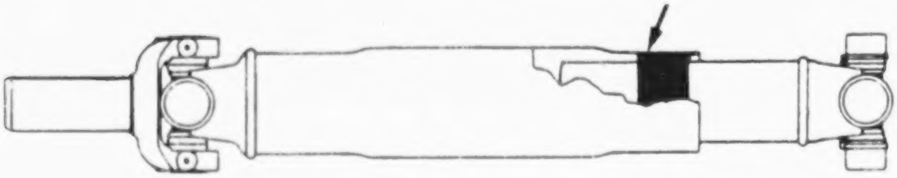
A. Vehicle vibration can also be controlled by attaching a vibration absorber to the transmission. The vibration absorber is a series of heavy steel plates, which are joined together and bolted to the transmission extension housing. The vibration absorber dampens any engine or drive-train vibrations produced during high-speed operation.



VIBRATION ABSORBER

B. An elastomer-sleeved propeller shaft is constructed of two tubes separated by a rubber-lined material that absorbs vibration and prevents "ringing."

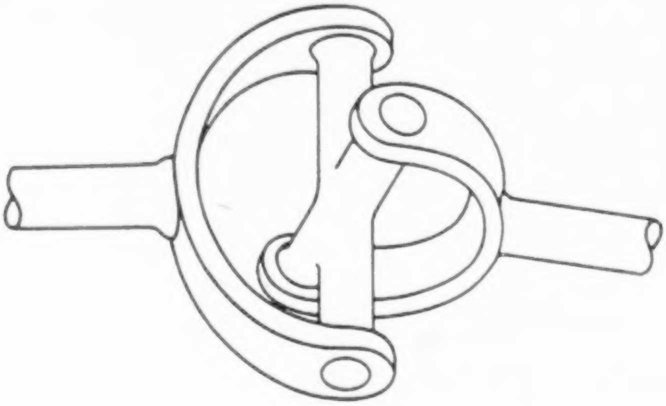
ELASTOMER SLEEVED PROPELLER SHAFT



V. Drive shaft and U-joint operation

A. Simple U-joint operation

1. A cardan universal joint is basically two Y-shaped yokes connected by an X-shaped crosspiece.



Courtesy of General Motors Corporation

2. The crosspiece allows the two yokes to operate at various angles to each other.

3. During drive shaft operation, the yoke that stays at the same angle operates at a constant velocity. The yoke that changes angles speeds up and slows down twice per revolution.

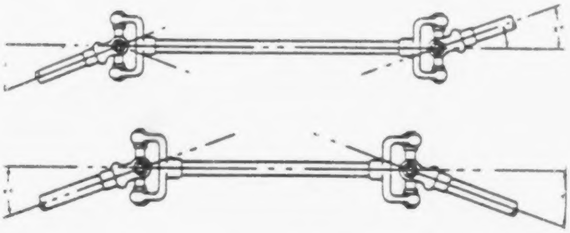
4. The greater the angle of operation, the greater the change in driven-yoke speed. This change in speed can result in significant drive train vibrations and can greatly increase the strain on the U-joint crosspiece. The chart below indicates the relationship between the angle at which the yoke operates and changes in the yoke's velocity.

Angle of Operation	Change in Velocity
4 degrees	.5%
10 degrees	3%
30 degrees	74%

B. One-piece drive shaft

1. To minimize the effect of velocity changes in a one-piece drive shaft assembly, the U-joints must be "phased."

2. The term "phased" means that the yokes at each end are welded exactly in line with each other. Since both the front and rear U-joints will operate at approximately the same angle in most driving conditions, yoke alignment causes the velocity-changing effect of one joint to cancel out the other. That is, if an operating angle causes the front U-joint to relay a changing velocity to the drive shaft tube, the similar operating angle of the rear U-joint will (if the joints are in proper alignment) change the nonconstant turning of the drive shaft tube into constant velocity at the differential companion flange. The only components that must change their turning velocity is the drive shaft tube and yokes. In this alignment, the U-joints are said to be "phased."



Courtesy of General Motors Corporation

3. Since the yokes on one-piece drive shaft assemblies are welded to the drive shaft tube, U-joint timing can change only if the tube develops a torsional twist.

C. The two-piece drive shaft with center support bearing uses an additional U-joint just behind the center support bearing. All three U-joints are timed (in line) to reduce problems that arise from changes in turning velocity.

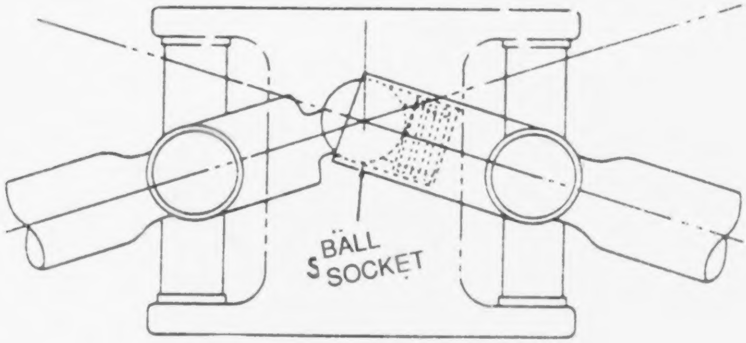
D. Double-cardan constant-velocity (CV) joints

1. Constant velocity joints are often found at the rear of the vehicle (at the differential) because this is the point at which the greatest changes in angle can occur. This is due to the combination of differential movement with suspension travel. It is also due to the differential's tendency to wrap up and down when the vehicle slows down or speeds up.

2. Because they are positioned close together and at equal input and output angles, the cardan joints cancel out changes in turning velocity. The only part that will still change in velocity is the link yoke. The link yoke, however, is relatively light in weight and produces little vibration.

3. The double-cardan constant-velocity joint can operate at almost any angle without transferring changes in velocity or causing vibration.

4. A ball and socket system is needed to stabilize the joint. The ball and socket prevent the link yoke from turning with wobble or runout.



SIMPLIFIED ILLUSTRATION OF CONSTANT VELOCITY JOINT

Courtesy of General Motors Corporation

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

LESSON 3: DRIVE SHAFT INSPECTION AND REPAIR

I. Drive shaft inspection

   A. Inspect U-joints by grasping the front slip yoke and flexing the joint. A defective U-joint will either be loose or rough and tight. Grasp rear U-joint and repeat.

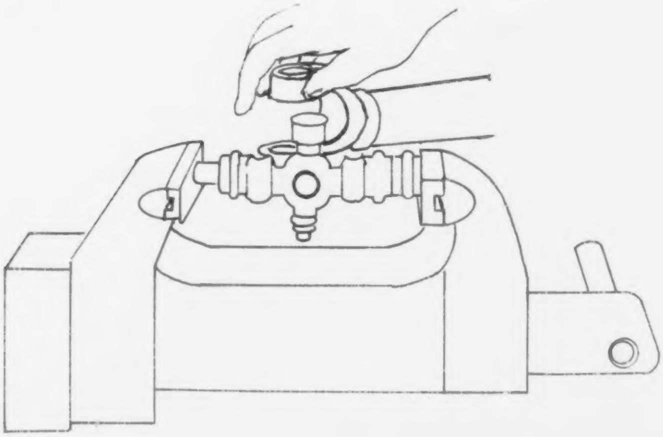
   B. Procedure for removing defective U-joint (vice press procedure)

      1. Remove lock rings from bearing cups (if used).

      2. Select a suitable pressing arbor or socket. The pressing tool must be smaller than the diameter of the bearing cup.

      3. Select a receiving socket into which the U-joint cap can be pressed. The socket must have an inside diameter larger than the bearing cup.

      4. Use a heavy-duty vise to push bearing cups through the yoke.



      5. Remove from vise. Remove the outside bearing cup from the yoke.

      6. Return to vise and press trunion in opposite direction to push out the other bearing cup.

7. Remove from vise. Remove the other bearing cup and crosspiece.

8. Clean and inspect dust seals, needle bearings, cups, and trunions. If all components are undamaged, the U-joint can be repacked with grease and reinstalled.

C. Procedure for inspecting drive shaft

1. Clean drive shaft tube and yokes.

2. Inspect tube for dents by turning on V-blocks while measuring runout. Dents usually indicate a bent shaft. Replace the drive shaft if dented.

3. Draw a straight line from the center of one yoke hole to the other end of the tube. The line should intersect the center of the other yoke hole. If the line does not do so, the shaft is either twisted or the yokes are welded out of phase. Replace the drive shaft if it is bent.

4. Inspect yokes for wear or out-of-round bearing cup holes. Replace the drive shaft or yoke if they are worn.

5. Inspect tube for missing balance weight. Have drive shaft rebalanced as necessary.

D. Procedure for inspecting center support bearing (carrier bearing) on two-piece drive shafts only

1. Clean center support and bearing.

2. Turn bearing by hand and check for roughness, looseness, or binding. Replace the center support bearing if it is defective.

   (NOTE: To replace the center support bearing, press the carrier bearing off the drive shaft and press on a new one.)

3. Inspect rubber collar and bracket for damage. Replace if defective.

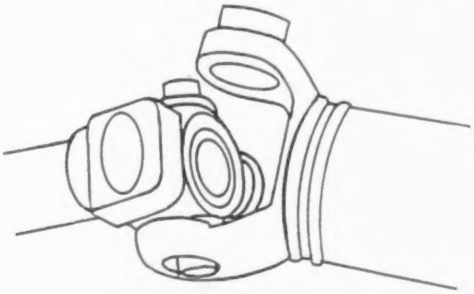
E. The condition of the centering ball mechanism on the double-cardan joint must be inspected after joint disassembly. Since procedures vary with type of joint, refer to an appropriate service manual for the procedure and special tools required.

II. Drive shaft assembly and installation

A. Procedure for installing a new or repacked U-joint

1. Remove all the traces of sheared plastic (if injected plastic type) from the grooves in the yoke and drive shaft cups.

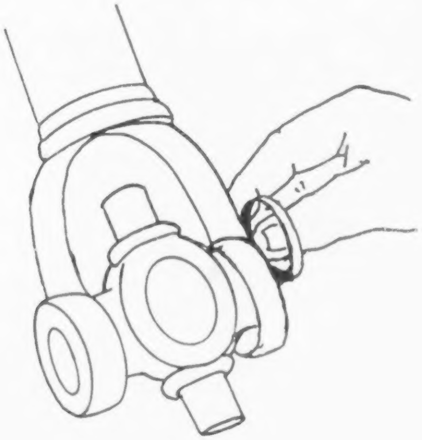
2. Push one bearing cup into the yoke and install the crosspiece.



3. Insert trunion part of the way into bearing cup.

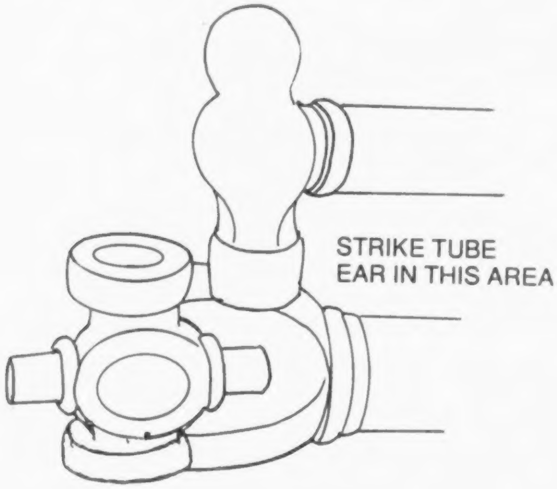
4. Install other bearing cup and press together in vise. Check crosspiece movement continuously for binding, which indicates misplacement of needle bearings. If binding occurs, remove cups and crosspiece and repeat procedure.

5. Press cups in until retainer clips can be installed. If the clips cannot be installed, a needle bearing may be turned sideways in the cup. Remove the U-joint from the yoke and repeat procedure.



INSTALLING SNAP RING TO RETAIN TRUNNION

6. Make sure final assembly can move freely. If the joint feels tight, center the U-joint by resting the cups or slip yoke on the jaws of the vise with a protective cloth in between the cups or slip yoke and the jaws of the vise. Next, gently tap the ears of the yoke to push the bearing cups out against the retainer clips.



SEATING SNAP RINGS

7. Wrap rear U-joint bearing cups with tape to keep them in place during installation.

   (NOTE: Never clamp the drive shaft tube in a vise or strike the yokes with a hammer while the tube is extending over the edge of a table. Doing so may bend the drive shaft tube.)

B. Procedure for installing drive shaft assembly (one-piece type)

   1. Lubricate the front slip yoke with a light oil. Insert the slip yoke into the transmission extension housing, engaging the splines of the transmission mainshaft (output shaft).

   2. Raise the rear U-joint into position with the differential companion flange. Remove the tape from the cups.

   3. Insert rear U-joint into companion flange so that bearing cups center in flange.

   4. Install and tighten U-bolts or clamps evenly. Do not over tighten.

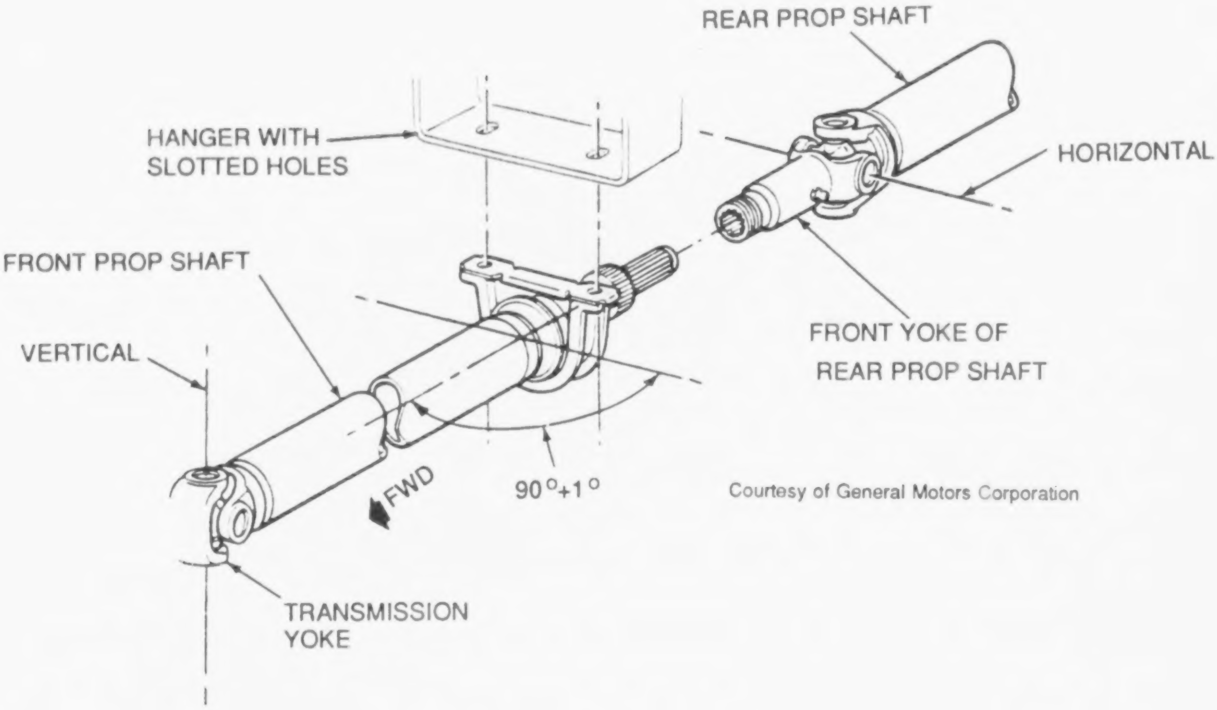
C. Drive shaft assembly installation (two-piece type)

   1. Lubricate the front slip yoke with a light oil. Insert the slip yoke into the transmission extension housing, engaging the splines of the transmission mainshaft.

2. Bolt center support bracket to frame. Maintain a 90° angle to the drive shaft with no strain on the bearing.

3. Lubricate the rear shaft slip yoke with a light oil. Insert the slip yoke into the front shaft splines, which extend from the rear of the center support bearing. Be sure to observe correct U-joint phasing.

   (**CAUTION**: All U-joints must be in line.)


REAR PROP SHAFT
HANGER WITH SLOTTED HOLES
HORIZONTAL
FRONT PROP SHAFT
VERTICAL
FRONT YOKE OF REAR PROP SHAFT
FWD
90°+1°
TRANSMISSION YOKE

Courtesy of General Motors Corporation

ALIGNMENT FOR PHASING

4. Raise rear U-joint into position with the differential companion flange. Remove tape from around the cups.

5. Insert rear U-joint into companion flange so that bearing cups center in flange.

6. Install and tighten U-bolts or straps evenly. Do not over tighten.

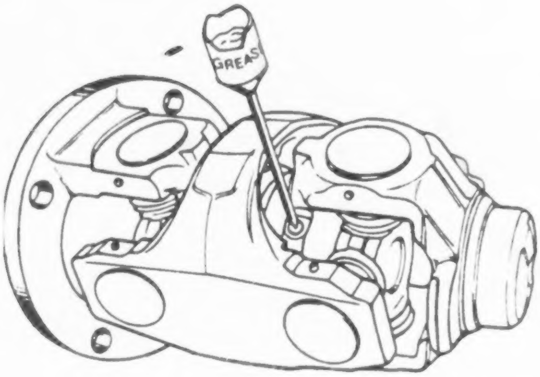
D. Procedure for drive shaft assembly installation (with rear CV joint)

   1. Lubricate front slip yoke with a light oil. Insert slip yoke into transmission extension housing, engaging the splines of the transmission mainshaft (output shaft).

   2. Raise the rear CV joint assembly into position and match to differential flange.

   3. Slide the bolts through the differential and into the rear CV joint flange. Tighten each bolt a little at a time so that the flanges pull together evenly. Make sure bolts are tightened to the specifications listed in the service manual.

E. Lubricate all grease fittings (zerk fittings) as found on U-joints and shafts.



Courtesy of General Motors Corporation

MODULE: MANUAL DRIVE TRAINS AND AXLES

SERVICING A DRIVE SHAFT

Equipment:

Hoist
Drain pan
Service light
U-bent press
Vise
Hand tools
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Place the car securely on safety stands or lift with hoist.	__ __ __ __
3. Following the procedure outlined below, diagnose drive shaft and universal joint problems.	__ __ __ __

   a. Inspect engine and transmission mount for looseness.

   b. Inspect differential control arms and bushings for looseness.

   c. Rotate drive shaft back and forth while observing the movement between the yokes.

   d. Inspect the drive shaft carrier bearing.

   e. Record observations and recommend steps that can be taken to correct any problems.

4. Following the procedure outlined below, service the drive shaft and universal joint.	__ __ __ __

   a. Remove the drive shaft from the vehicle. For the proper procedure, refer to section V or VI of Lesson 1 in this unit.

b. Replace defective or worn drive shaft components. Refer to either the procedure in the information sheets or the procedure which comes with the new component.

c. Reinstall the drive shaft.

d. Rotate the drive shaft while observing whether it moves freely.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Bb1 and the final evaluation for Competency Bb3. Final evaluation for Bb1 will be made at the end of JS1-L2-UX.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VI: DRIVE SHAFT DIAGNOSIS AND REPAIR

UNIT VI TEST

SECTION A. Match the terms below with their correct definitions.

____ 1. A type of U-joint consisting of a crosspiece and bearing cups that join with yokes on either side.

____ 2. A flexible coupling which allows a driving shaft and a driven shaft to operate despite changes in angle between them.

____ 3. Any type of drive shaft joint that delivers smooth turning motion regardless of the angle at which the joint must operate.

____ 4. A flange that couples a universal joint to a shaft.

____ 5. One of the machined journals of the U-joint crosspiece on which the bearing turns.

____ 6. The steel center portion of the cardan universal joint that has four machined trunions on which the bearing cups turn.

____ 7. The steel yoke that couples the rear U-joint to the differential drive pinion gear.

a. Cardan joint

b. Constant velocity joint

c. Companion flange

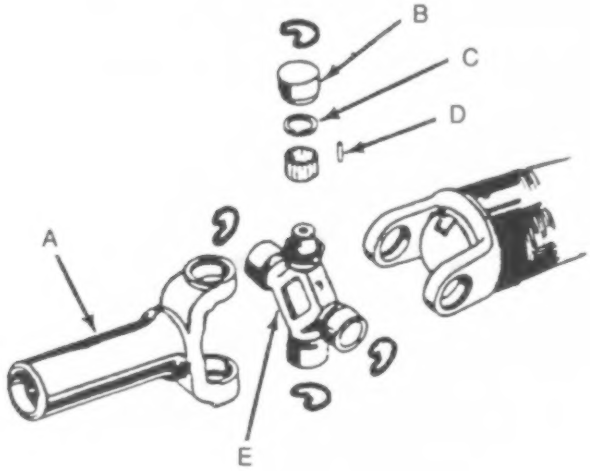
d. Crosspiece

e. Trunion

ab. Universal joint

ac. Yoke

SECTION B. Shown below are various components of a universal joint. Identify the components of the universal joint by matching the letter of the part with the name of the part.



Courtesy of Mitchell Information Services, Inc.

____ 8. Bearings

____ 9. Bearing cup

____ 10. Trunion (cross)

____ 11. Slip yoke

____ 12. Seal

SECTION C. Select the best answer from the five choices listed.

____ 13. When the vehicle is moving, the differential will move up and down in relation to the transmission. This up and down movement requires the drive shaft to change length while operating. The slip yoke accommodates this change in length by

a. continually lubricating the drive shaft during operation.
b. changing angles with drive shaft movement.
c. sliding in and out of the transmission housing on a bushing.
d. pivoting on a rubber bushing in relation to drive shaft movement.
e. doing none of the above.

____ 14. A drive shaft can best be described as

a. an aluminum tube.
b. an aluminum tube with a steel center.
c. a steel tube with an aluminum center.
d a steel-lined plastic tube.
e. none of the above.

____ 15. Steel yokes are welded at each end of the drive shaft tube to join with the

a. engine crankshaft and rear axle.
b. U-joints.
c. engine crankshaft and the differential.
d. clutch assembly and rear axle.
e. vehicle's frame.

____ 16. On nonconstant velocity (single-cardan) drive shaft assemblies, the rear U-joint

a. may be the same size as the front U-joint but have different parts.
b. may be a different size than the front U-joint but have the same parts.
c. will always be the same size as the front U-joint but may have different parts.
d. will always be a different size than the front U-joint but will have the same parts.
e. will always be half the size of the front U-joint.

____ 17. One advantage of a two-piece drive shaft is that it maintains maximum differential movement while

a. allowing for easier lubrication.
b. reducing "ringing" of the drive shaft.
c. providing more support for the differential.
d. while distributing the weight of the drive shaft more evenly.
e. reducing the height of the drive shaft tunnel in the interior.

____ 18. In addition to the same components found in a one-piece drive shaft, a two-piece drive shaft contains

a. counter balance weights.
b. a link and pin connecting assembly.
c. a self-lubricating bearing/bushing assembly.
d. an extra bearing cup and trunion.
e. a carrier bearing and slip yoke.

____ 19. Constant velocity U-joints are able to reduce torsional vibrations because they

a. maintain a constant turning speed.
b. are able to accommodate changes in the length of a drive shaft.
c. are larger than conventional U-joints and thus can provide greater support for the drive shaft.
d. provide a gear reduction for the drive shaft.
e. provide a gear reduction for the engine crankshaft.

SECTION D. Read each statement carefully and indicate whether it is true or false by placing a T or F in the blank beside it.

____ 20. Elastomer sleeved propeller shafts are used to eliminate vibration.

____ 21. A cardan U-joint is basically two Y-shaped yokes connected by an X-shaped crosspiece.

____ 22. The crosspiece in a cardan U-joint allows the two yokes to operate at an angle to each other.

____ 23. The yokes at each end of a one-piece drive shaft are welded slightly out of line with each other to allow the velocity-changing effect of one joint to cancel out the velocity-changing effect of the other.

____ 24. Constant velocity U-joints are often found at the rear of the vehicle (at the differential).

____ 25. The double-cardan constant velocity joint can operate at almost any angle without transmitting changes in velocity.

____ 26. The two-piece drive shaft uses four U-joints.

____ 27. On one-piece drive shaft assemblies, yokes are usually connected to the drive shaft with a link pin.

____ 28. A ball and socket system is necessary to stabilize a double-cardan constant velocity U-joint.

SECTION E. Select the best answer from the five choices listed.

____ 29. A defective U-joint will be

a. loose.
b. rough.
c. tight.
d. any of the above.
e. none of the above.

____ 30. When removing a defective U-joint, the technician should push bearing cups through the yoke with the aid of

a. a ball-peen hammer.
b. a small steel rod.
c. a hammer and punch.
d. a heavy-duty vise.
e. none of the above.

____ 31. Dents in the drive shaft tube indicate that

a. the shaft may be bent.
b. the universal joints are loose.
c. the yokes are not securely in place.
d. vibration absorbers are loose.
e. torsional vibration dampers are loose.

____ 32. To ensure that the drive shaft tube is not twisted and that the yolks are not welded out of place, the technician should

a. draw a straight line down the drive shaft tube and make sure that the line intersects both yolk holes.
b. fit the yolk holes over two pegs that are in precise alignment with each other.
c. roll the tube across a hard, level surface.
d. place a level on the tube.
e. compare the tube with one that is known to be straight.

____ 33. When a technician says that U-joints are correctly phased, he or she means they are

a. correctly sized.
b. in perfect alignment.
c. timed so as to maintain a precise difference in velocity during operation.
d. all of the above.
e. none of the above.

(NOTE: The student must obtain a minimum score of _____ on the Unit VI Test in order to receive an evaluation for Competencies Bb1 and Bb3.)

ANSWERS TO UNIT VI TEST

1. a
2. ab
3. b
4. ac
5. e
6. d
7. c
8. d
9. b
10. e
11. a
12. c
13. c
14. e
15. b
16. b
17. e
18. e
19. c
20. t
21. t
22. t
23. f
24. t
25. t
26. f
27. f
28. t
29. d
30. d
31. a
32. a
33. b

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VII: DIFFERENTIAL COMPONENTS AND THEIR OPERATION

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various components of the differential and the principles by which these components operate. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student will be able to:

Lesson 1. I. Identify terms and definitions associated with the components and operation of the differential (Competencies Cc1-Cc3, Unit VII Test).

II. Identify various styles of differential housings (Competencies Cc1-Cc3, Unit VII Test).

III. Identify the function and design of differential gears (Competencies Cc1-Cc3, Unit VII Test).

IV. Identify the manner in which a standard differential operates (Competencies Cc1-Cc3, Unit VII Test).

V. Identify the manner in which a limited-slip differential operates (Competencies Cc1-Cc3, Unit VII Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VII: DIFFERENTIAL COMPONENTS AND THEIR OPERATION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DIFFERENTIAL COMPONENT DESIGN

    a. Information outline

    b. Assignment sheets

      AS1-L1-UVII: Differential Operation

E. Unit test

F. Answers to unit test

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DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-VII before taking the Unit VII test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. The Principles of the Differential (AM-84-450), 1984.

   2. Pinion Seal Replacement (AM-84-451), 1984.

   3. Axle Bearing and Seal Replacement (AM-84-452), 1984.

   4. Final Drive Adjustments (AM-84-453), 1984.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VII: DIFFERENTIAL COMPONENTS AND THEIR OPERATION

LESSON 1: DIFFERENTIAL COMPONENT DESIGN

I. Terms and definitions

A. Axle, full-floating--An axle that drives the rear wheel without supporting the vehicle's weight. On vehicles with full-floating axles, the weight is supported by hubs, which spin on inner and outer wheel bearings.

B. Axle, semi-floating--An axle that drives the rear wheel and also supports the vehicle's weight.

C. Axle, three-quarter floating--An axle that drives the wheel and is bolted to the hub. The three-quarter floating axle does not support the vehicle's weight. The weight is supported by the hubs, which spin on inner and outer wheel bearings.

D. Axle housing--The enclosure for the differential and axle components.

E. Axle side gears--The two bevel gears that are splined to the axle ends within the axle housing. The axle side gears are turned by the differential pinion (spider) gears.

F. Bevel gear--A cone-shaped gear that meshes with a similarly beveled gear in order to change the angle between the driving and driven shafts (usually a 90° or right angle).

G. Brake backing plate--A stamped steel plate which is bolted to the flanges at the differential tube ends. The plate provides a mounting for the drum brake components.

H. Differential case--A cast iron or steel housing that has a ring gear bolted to it. The differential case contains the gears that drive the axle shafts. The differential case spins on carrier bearings located at each end of the case.

I. Differential pinion gears (spider gears)--Bevel gears located inside the differential case. The differential pinion gears drive the axle side gears. Differential pinion gears are free to spin on a pinion shaft in order to compensate for different turning speeds of the axle shafts.

J. Drive pinion gear--The bevel gear that meshes with the ring gear. Drive pinion gear is splined on the end to join with the drive-shaft/U-joint companion flange (differential companion flange). The drive pinion gear turns on a pair of inward-facing, tapered roller bearings.

K. Final drive ratio--The gear ratio of the differential. Final drive ratio is established by the number of teeth on the ring and drive pinion gears.

L. Hunting gears--A gear set consisting of a ring gear and a drive pinion gear. In a hunting gear set, every time the pinion gear makes one revolution, its teeth engage the ring gear at a different point. Thus the teeth on the pinion gear will never contact the same teeth on the ring gear twice in a row.

M. Hypoid gear--A type of ring and drive pinion gear set in which the center line of the drive pinion gear is below the center line of the ring gear.

N. Limited-slip differential--A type of differential in which the axles are allowed to turn independently only through a clutch or locking mechanism.

O. Live axle--An axle that drives a wheel.

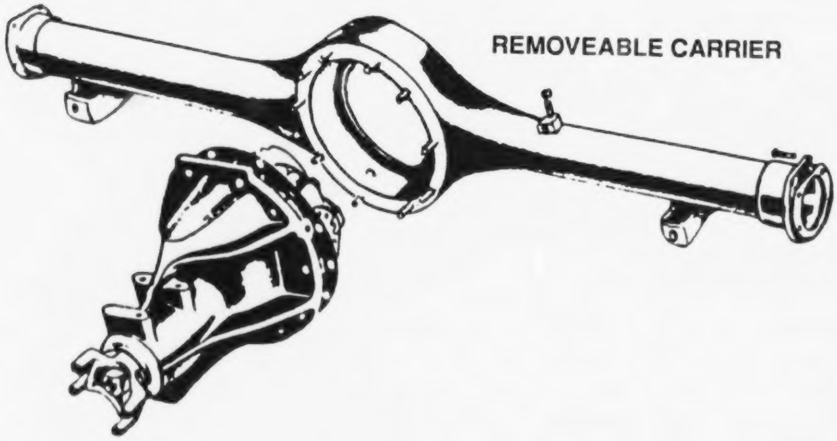
P. Nonhunting gears--A gear set consisting of a ring gear and a drive pinion gear. In a nonhunting gear set, every time the pinion gear makes one revolution, its teeth engage the ring gear at the same point. Thus the teeth on the pinion gear will always contact the same teeth on the ring gear.

Q. Ring gear--A large gear which bolts to the differential case and meshes with the drive pinion gear.

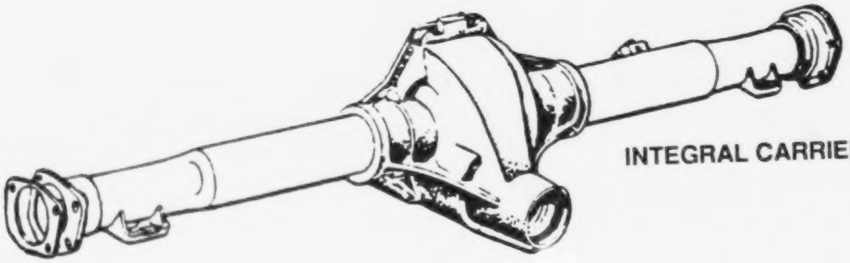
II. Types of differential housing and axles

A. Differential housing styles

1. The third-member differential uses a removable carrier and a one-piece axle tube. The third-member differential housing is sometimes referred to as a "banjo housing."



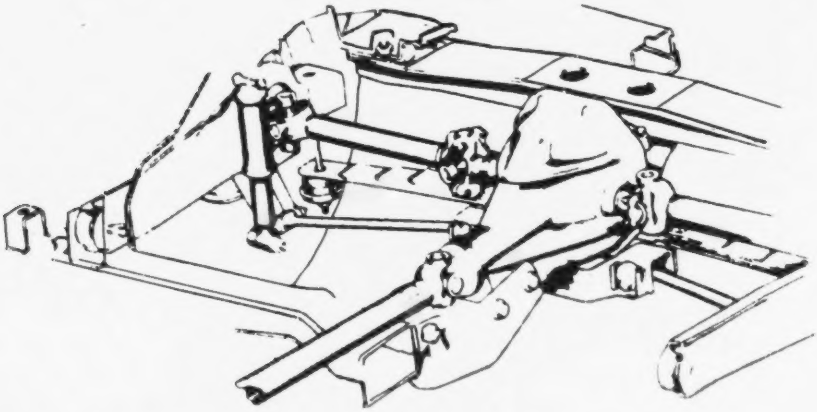
2. The integral carrier differential is constructed as a complete unit; therefore, it is usually not removed from the vehicle when serviced. The rear inspection cover can be removed to gain access to the internal components.



INTEGRAL CARRIER

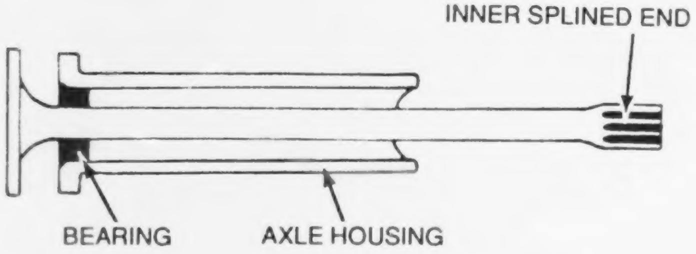
3. Independent rear suspension uses a central differential housing to which the independent axle shafts are connected. One rear wheel can deflect to accommodate a road bump without transferring movement directly to the other side.

INDEPENDENT REAR SUSPENSION



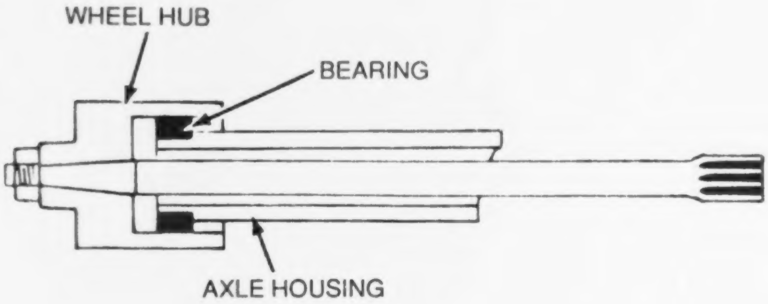
B. Axle shaft styles

1. The semi-floating axle attaches to the wheel. The semi-floating axle both supports vehicle weight and turns the wheel. If this axle were to break, the wheel could easily come off the vehicle. For this reason, it is used in automobiles and light-duty trucks that do not undergo great stress.


INNER SPLINED END
BEARING
AXLE HOUSING

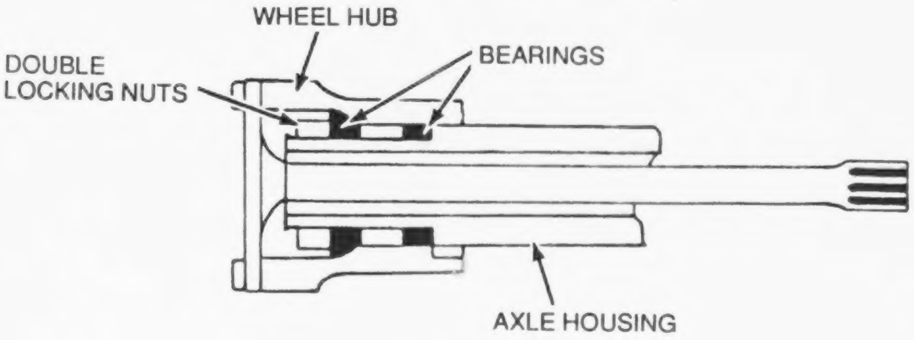
SEMI-FLOATING

2. The three-quarter floating axle uses the axle shaft to drive the wheel. The axle shaft also holds the wheel on the vehicle. Vehicle weight, however, is supported by hubs and bearings, which transfer the load to the axle housing. The three-quarter axle design can be found on medium-duty trucks.


WHEEL HUB
BEARING
AXLE HOUSING

THREE -QUARTER FLOATING

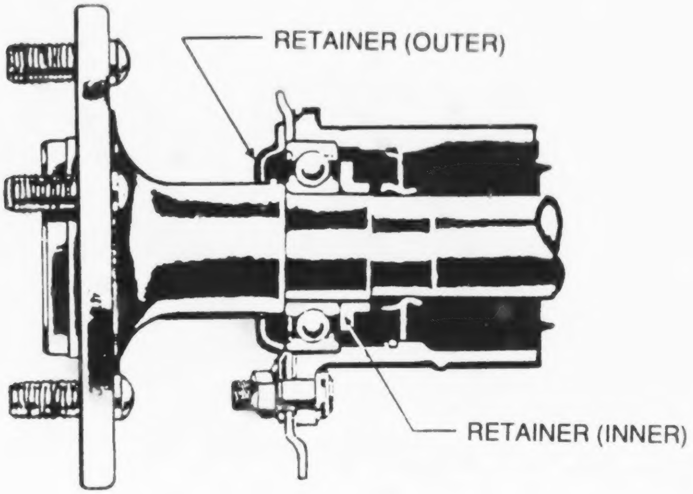
3. In the full-floating axle arrangement, the axle's sole function is to drive the wheels; the hubs and bearings support the vehicle's weight. A large retainer holds the bearings on the differential housing. The bearings, in turn, hold the wheels on the vehicle. The hubs and bearings transfer the load to the axle housing tubes. If an axle shaft breaks, the wheel will not come off, but it will lose driving power. The full-floating axle arrangement is stronger and safer under great loads and is, therefore, found on heavy-duty trucks and some race cars.



FULL-FLOATING

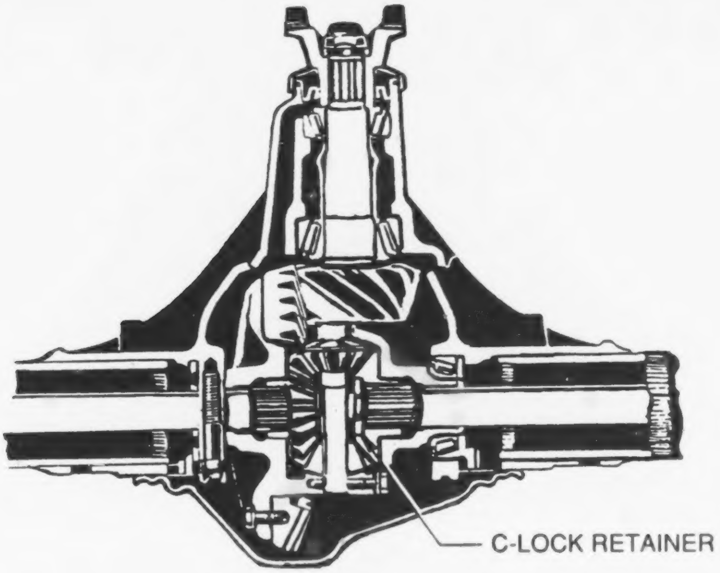
C. On semi-floating axles, there are two designs that retain axles in the housing: the press-fit bearing and retainer plate design and the C-lock design.

1. The press-fit bearing and retainer plate design utilizes a bearing and sometimes an additional collar, which are pressed with great force onto the axle near the wheel hub. Either a retainer plate or the brake backing plate holds this bearing (and axle shaft) in the housing when bolted to the flange on the axle housing tube. If the axle were to break inside the axle tube, the wheel would lean, yet it would probably not come off the vehicle.



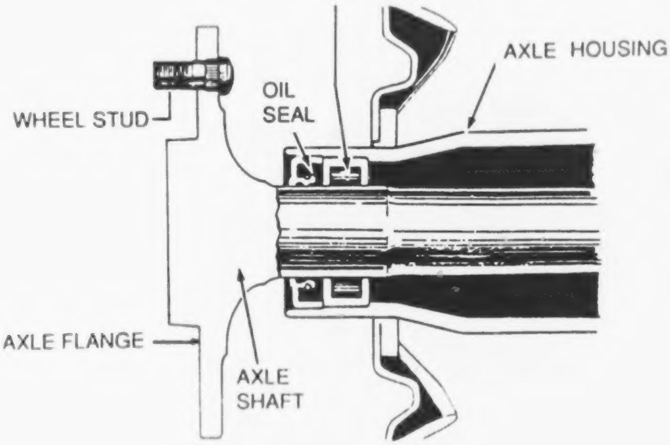
EXTERNAL BEARING RETAINER

2. In the C-lock axle assembly a bearing supports the axle. The flange end of the axle shaft is supported by the brake backing plate. However, since the bearing is not pressed onto the axle shaft, it cannot retain the shaft. Instead, the axle has a machined groove near the inner shaft end. A C-shaped clip is inserted in the grove after the axle is slipped into the center section of the differential. The C-lock fits into a recess, which prevents it from falling out. If, however, the axle shaft breaks, the axle and wheel can leave the axle housing and come off the vehicle.

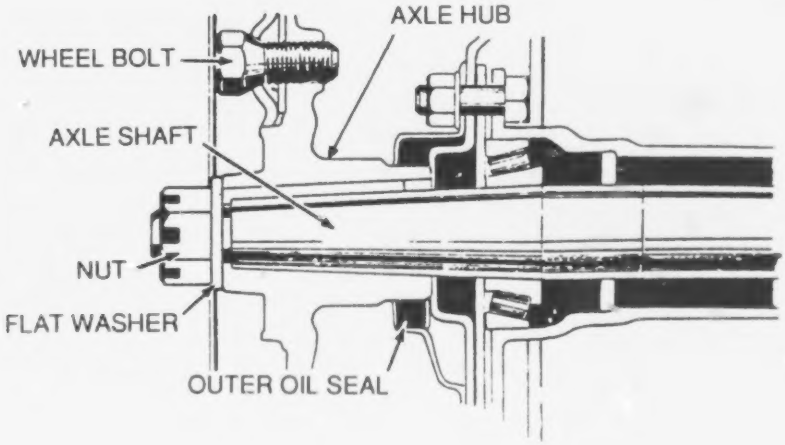


D. Attaching the wheel to the axle

1 On semi-floating designs, the axle flange is an integral part of the axle shaft. Lug bolts, or lug nuts and studs, hold the wheel to the flange.



2. On three-quarter floating designs, the axle flange is connected to the axle shaft by way of a tapered inner surface or splines. The tapered inner surface or splines are held to the axle shaft with a nut. Lug bolts, or lug nuts and studs, hold the wheel to the flange.

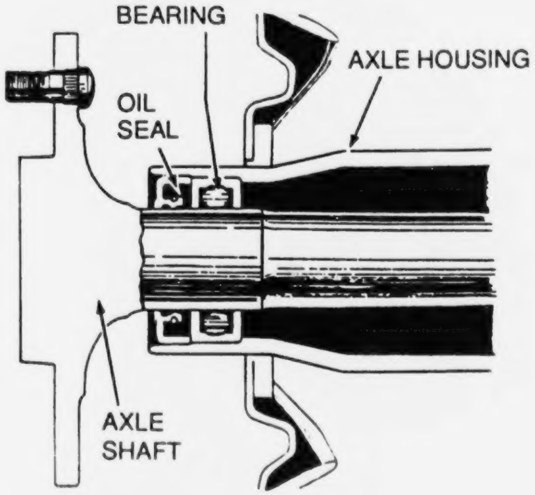


3. On full-floating designs, the axle flange is part of the hub and is held onto the axle housing tube with two large tapered roller bearings (inner and outer) and a nut. The hub is splined to the axle shaft and is held in place by a retainer plate, which is bolted to the hub. Lug bolts, or lug nuts and studs, hold the wheel to the flange.

E. Lubrication of wheel bearings

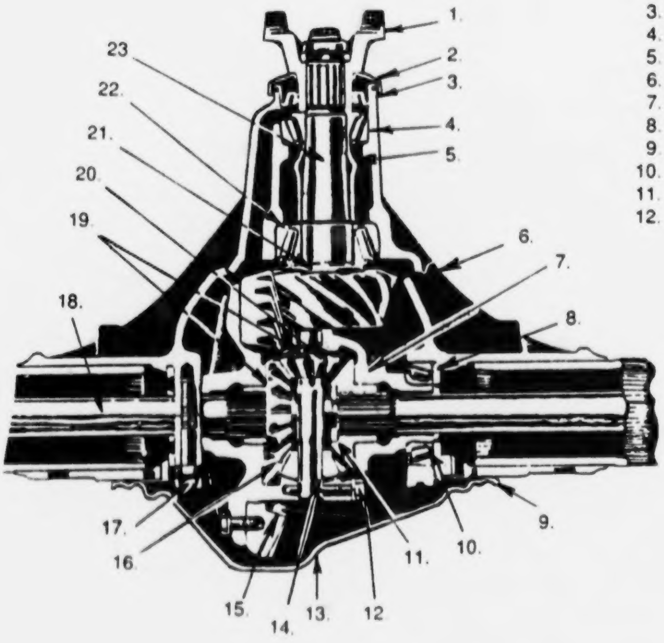
1. Gear lube from the center section of the differential splashes on the wheel bearings during vehicle cornering.

2. Seals near the wheel bearings retain gear lube in the axle housing.


BEARING
AXLE HOUSING
OIL SEAL
AXLE SHAFT

III. Differential gear design and function

REAL AXLE DIFFERENTIAL CROSS SECTION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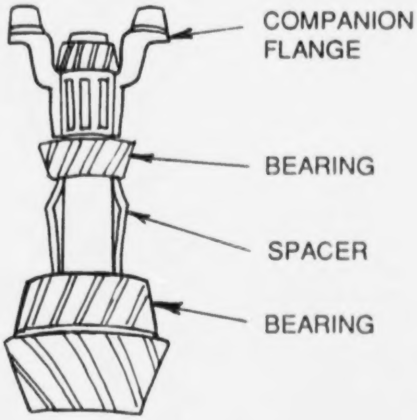
1. COMPANION FLANGE
2. DEFLECTOR
3. PINION OIL SEAL
4. PINION FRONT BEARING
5. PINION BEARING SPACER
6. DIFFERENTIAL CARRIER
7. DIFFERENTIAL CASE
8. SHIM
9. GASKET
10. DIFFERENTIAL BEARING
11. "C" LOCK
12. PINION SHAFT LOCK BOLT
13. COVER
14. PINION SHAFT
15. RING GEAR
16. SIDE GEAR
17. BEARING CAP
18. AXLE SHAFT
19. THRUST WASHER
20. DIFFERENTIAL PINION
21. SHIM
22. PINION
23. DRIVE PINION

A. Drive pinion gear

1. The drive pinion gear transfers turning power to the differential from the drive shaft to the ring gear.

2. The drive pinion gear is connected to the rear U-joint by a companion flange and U-bolts or straps.



3. A pair of inward-facing, tapered roller bearings are located on the drive pinion shaft. These bearings hold the drive pinion shaft in place for precise engagement with the ring gear.

B. Ring gear

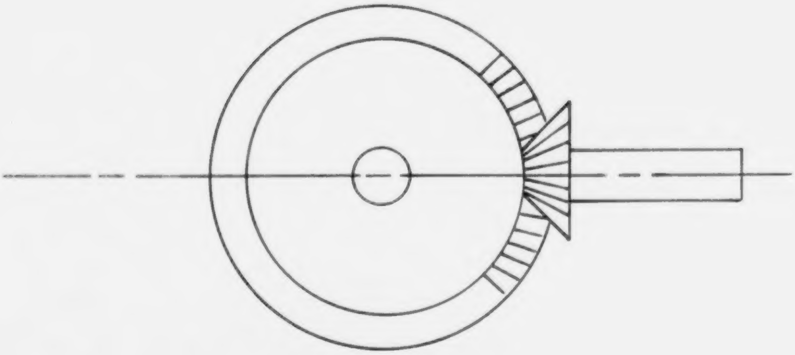
1. The ring gear engages the drive pinion gear and is turned at a right angle to it.

2. The ring gear is mounted on the differential case. When driven by the pinion gear, the ring gear rotates the differential case.

C. Types of ring and drive pinion gears

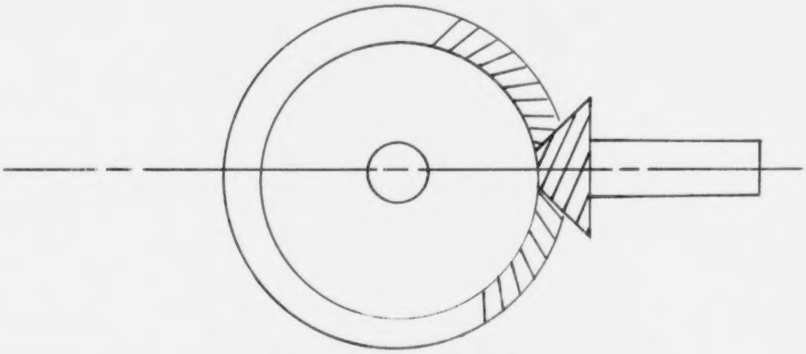
1. Spur bevel gears have straight-cut teeth on a bevel so that the gears rotate at a right angle to each other. Like all spur gears, spur bevel gears are sturdy but produce a loud whine while turning.

   (NOTE: The automotive industry rarely uses spur bevel gears.)



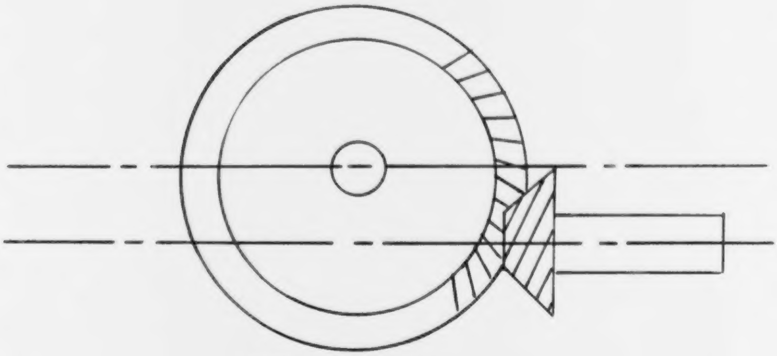
SPUR BEVEL GEAR

2. Spiral bevel gears are an improvement over the spur bevel design. Spiral bevel gears run more quietly at high speed.



SPIRAL BEVEL GEAR

3. The hypoid gear is similar to the spiral bevel gear design. In the hypoid design, however, the center line of the drive-pinion gear is somewhat lower than the center line of the ring gear. This arrangement has the advantage of allowing for a lower drive shaft tunnel, which results in more floorboard space. Like the spiral bevel gear, the hypoid gear runs quietly at high speed. The hypoid gear design is, therefore, the most common one used on vehicles today.



HYPOID GEAR

D. Differential case

1. The differential case is made of cast iron or steel.

2. The ring gear is bolted to the differential case, allowing the gear to turn the case.

3. The ring gear and the differential carrier spin on inward-facing, tapered roller bearings called carrier bearings. These hold the case and ring gear in precise alignment with the drive pinion gear.

4. The remaining differential gears are contained inside the ring gear (differential case).

E. Differential pinion gears (spider gears) and shaft

1. A steel shaft mounts across the interior of the differential case.

2. This differential pinion shaft is held in place with a retaining bolt.

3. Two spur bevel gears (called the differential pinion gears) spin on the pinion shaft.

4. These differential pinion gears mesh with the axle side gears. Differential pinion gears deliver power to the axle side gears by spinning end over end.

F. Axle side gears

1. The axle side gears are spur bevel gears that mesh at a right angle with the differential pinion gears.

2. These axle side gears are splined on the inside to connect with the axles.

3. The backside of the axle side gears is very smooth so that the gears can turn with a minimum amount of friction in the differential case.

4. Shim washers hold the differential carrier between the ring gear and the pinion gears. Shim washers also reduce friction against the differential case when high loads produce a thrusting side force.

IV. Differential operation (standard types)

A. In the differential, the ring gear operates both at a right angle to the drive pinion gear and at a low gear ratio. Typical gear ratios for automobile differentials range from a high of approximately 2 to 1 to a low of about 4 to 1. This means that the drive shaft and drive pinion gear will spin about 2 to 4 times for each complete revolution of the ring gear and the axles.

B. Differential gear ratio, or final drive ratio, is calculated by dividing the number of teeth on the ring gear by the number of teeth on the drive pinion gear. All ratios are expressed to 1. Example:

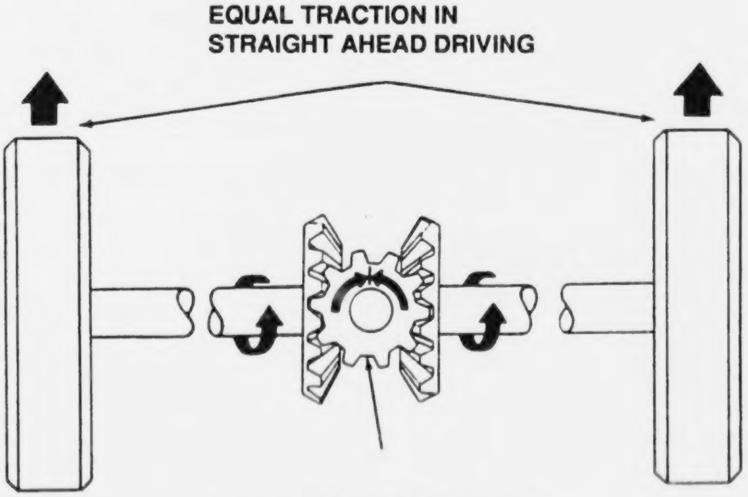
1. The number of ring gear teeth is 40.
2. The number of drive pinion gear teeth is 13.
3. 40 divided by 13 = 3.077 (round off to the nearest hundredth, 3.08)
4. The final drive ratio is 3.08 to 1.

C. The final drive ratio is selected by the manufacturer (or mechanic) based on the amount of pulling power desired and the diameter of the tires. Low ratios (near or greater than 4 to 1) are necessary for vehicles that have large tires or are designed for pulling heavy loads. High ratios (closer to 2 to 1) are necessary for vehicles with small tires. Vehicles that are designed for greater speed or fuel mileage also use high gear ratios.

D. Differential operation during straight ahead driving

1. The drive pinion gear drives the ring gear.
2. The ring gear turns the differential case on its carrier bearings.
3. The differential pinion shaft turns end over end.
4. The differential pinion gears and the axle side gears turn end over end.
5. The differential pinion gears and axle side gears do not spin. Instead they drive the axle side gears with an equal amount of torque.
6. The axle side gears, splined to the axles, deliver turning power to the axle shafts.

7. The axle shafts are supported by the axle bearings. The shafts connect through hubs or flanges to the driving wheels. These wheels are turning at the same speed, since the vehicle is moving straight down the road; therefore, the axles and axle side gears are turning at the same speed. No rotation is transferred to the differential pinion gears.



BALANCED FORCES MAKE DIFFERENTIAL SEEM LOCKED (DIFFERENTIAL NOT ACTIVE FOR STRAIGHT DRIVING)

Courtesy of General Motors Corporation

E. Differential operation while vehicle is cornering

1. The drive pinion gear drives the ring gear.

2. The ring gear turns the differential case on its carrier bearings.

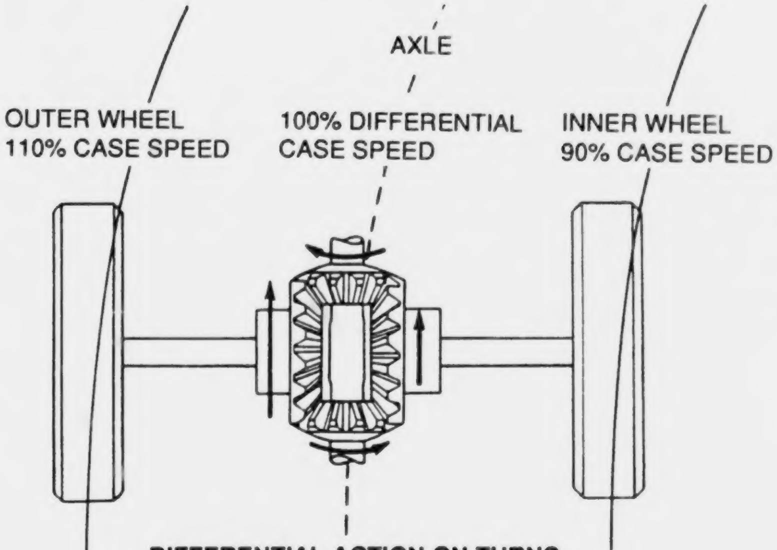
3. The differential pinion shaft turns end over end.

4. The differential gears on the shaft turn end over end and spin on their axis.

5. The side gears are driven by the differential pinion gears, which are turning end over end as well as spinning at different speeds.

6. The axle side gears, splined to the axles, deliver turning power to the axle shafts.

7. Because the axle shafts are connected to the wheels, the shafts must turn with the wheels. Since the vehicle is in a turn, the outside wheel is turning faster than the inside wheel. The different turning speeds of the wheels cause the outside axle shaft and side gear to spin faster than the inside axle shaft and side gear. The different turning speeds of the axle side gears cause the differential pinion gears to spin in order to compensate. Power is delivered to both wheels, but at different speeds.


AXLE
OUTER WHEEL
110% CASE SPEED
100% DIFFERENTIAL
CASE SPEED
INNER WHEEL
90% CASE SPEED

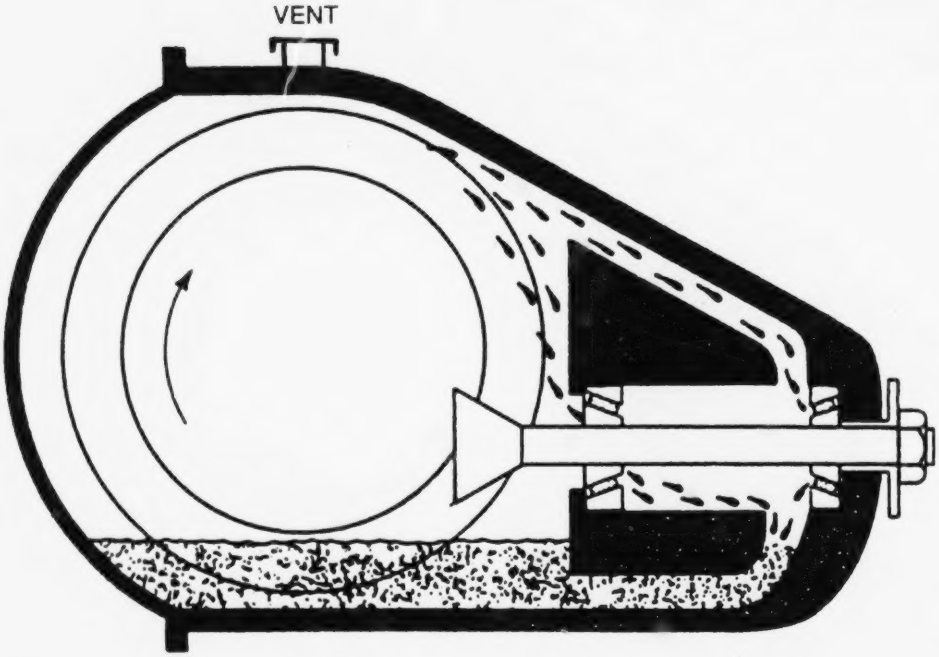
DIFFERENTIAL ACTION ON TURNS

Courtesy of General Motors Corporation

F. Lubrication of differential gears

1. Differential gear lubricant should be of a heavy, single viscosity such as 90 weight, or of a multiviscosity such as 80W85W90. Heavy duty vehicles may specify an even higher viscosity gear lube. Always refer to the manufacturer's recommendations for the proper type of lubricant.

2. Gear lubricant is picked up by the spinning ring gear and directed through passageways to the drive pinion bearings. Lubricant also splashes on the carrier bearings, differential pinion gears, axle side gears, and wheel bearings.



3. A vent at the top of the axle housing prevents pressure build up, which may occur as the differential becomes hot during operation.

4. A fill plug is located about halfway up on the center section of the housing or on the rear inspection cover. Gear lubricant is added through this opening until the lubricant is within about 1/4 inch from the bottom of the hole. The lubricant level can be checked by bending the little finger at the end knuckle and reaching into the opening. If the finger does not contact lubricant, more should be added.

V. Differential operation (limited-slip types)

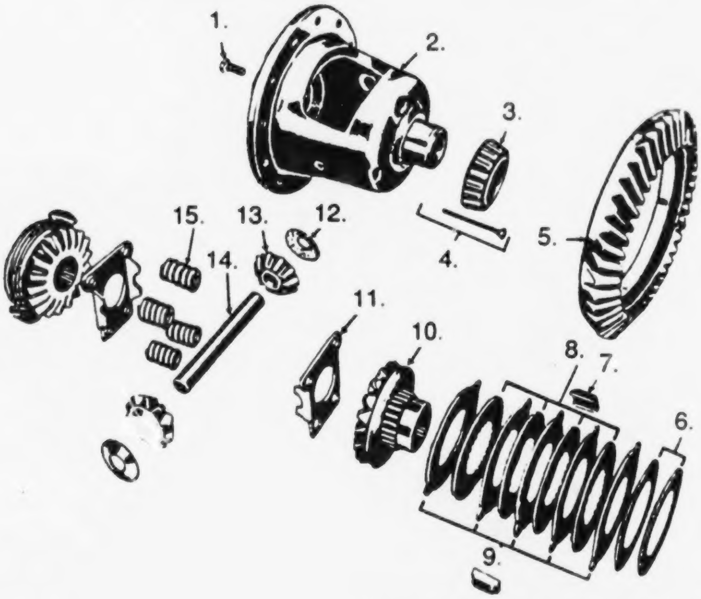
A. The problem of differential slip

1. A standard differential allows the driving wheels and axles to turn at different speeds. If one wheel has poor traction, it will spin at speeds greater than indicated by the speedometer. The other wheel (if it has adequate traction) will stand still and prevent the vehicle from moving. This situation is referred to as differential slip.

2. Differential slip can occur if the vehicle is on ice or extremely uneven pavement. Differential slip can also occur as a result of fast acceleration, which causes axle housing torque (opposite to that of the engine) to unload and reduce traction on the right rear wheel.

3. Some vehicles are equipped with a system to eliminate or reduce differential slip by resisting independent turning of the axles, especially under load. Such systems are referred to as limited slip or positive traction systems.

4. Limited slip differentials contain many of the same components as the standard (open) differential. Also, both types of differentials operate in a similar manner under most conditions. The differences involve the construction and operation of the axle side gears.



Courtesy of General Motors Corporation

1. RING GEAR-TO-CASE
2. DIFFERENTIAL CASE
3. SIDE BEARING
4. PINION LOCK SCREW AND WASHER
5. RING GEAR
6. SHIM
7. CLUTCH PACK GUIDE
8. CLUTCH DISC
9. CLUTCH PLATES
10. SIDE GEAR
11. SPRING RETAINER
12. PINION THRUST WASHER
13. PINION GEAR
14. PINION SHAFT
15. PRELOAD SPRING

B. Clutch plate limited-slip differential

1. Instead of friction-reducing shim washers between the inside of the differential case and the back of the axle side gears, a series of clutch plates limit differential slippage. In a limited-slip differential, this series of clutch plates is referred to as a clutch pack.

2. Springs and plates push outward against the axle slip gear to keep some preload pressure on the clutch packs.

3. The clutch packs will create some limited resistance to the turning of the side gears at a speed different from that of the case.

4. As more power and torque is relayed to the differential during vehicle acceleration, the axle side gears begin to unmesh and thus thrust outward toward the differential case.

5. As the side gears unmesh, greater pressure is applied to the clutch pack, creating even greater friction between the axle side gears and the differential case. The axles and side gears will slip very little, if at all, and therefore turn in unison.

6. This locking together of the axles allows both of the wheels to drive with equal torque.

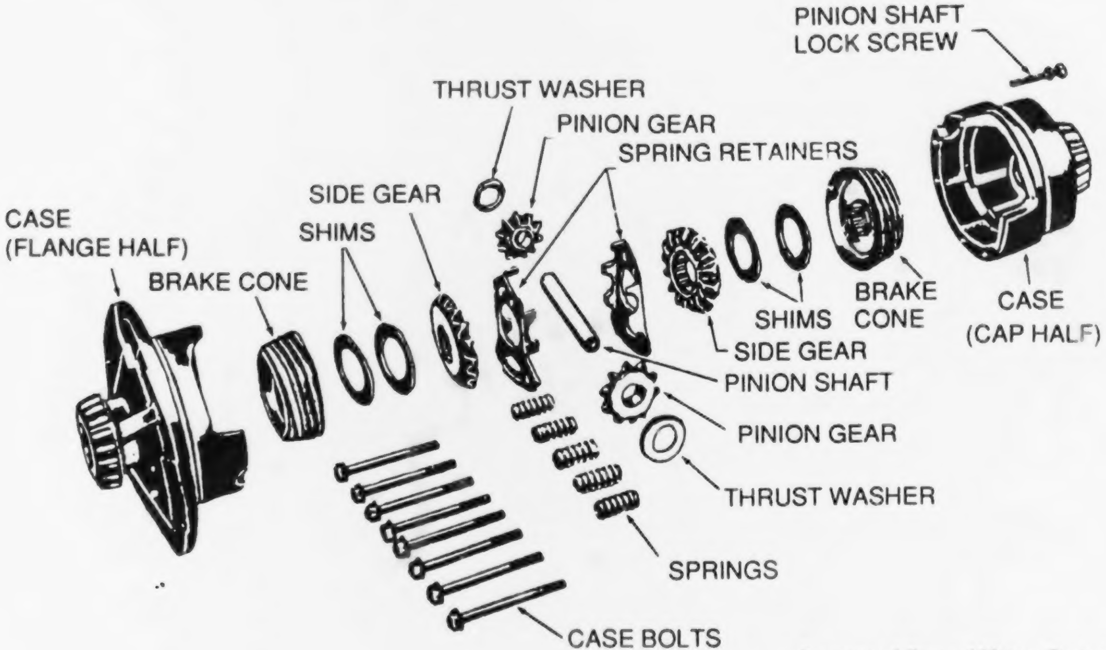
7. When the vehicle approaches a turn, the driver will ease pressure on the accelerator pedal and reduce the torque to the differential.

8. This reduction of torque eases the thrusting pressure against the clutch packs; therefore limited slipping of the axle side gears can occur. Limited slipping of the axle side gears allows the wheels to turn at different speeds while the vehicle goes through the turn.

C. Cone-shaped friction-surface limited-slip differentials

1. This design incorporates axle side gears, which have a cone-shaped friction surface. This surface fits another cone surface that is machined into the differential case.

2. During vehicle acceleration, these mating cone surfaces provide friction as the side gears are thrust outward. Some initial preload is provided by a series of springs between the side gears.


PINION SHAFT LOCK SCREW
THRUST WASHER
PINION GEAR
SPRING RETAINERS
SIDE GEAR
CASE (FLANGE HALF)
SHIMS
BRAKE CONE
BRAKE CONE
SHIMS
CASE (CAP HALF)
SIDE GEAR
PINION SHAFT
PINION GEAR
THRUST WASHER
SPRINGS
CASE BOLTS

Courtesy of General Motors Corporation

D. Gear lube for limited slip differentials must be specially formulated because there must be a controlled amount of grip between the clutch plates or cone surfaces. Failure to use the proper gear lube can result in differential chattering (a noise and vibration that can jar the vehicle). Refer to the manufacturer's recommendations for the proper type of gear lube. All other lubricating action is the same as in standard (open) differentials.

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIFFERENTIAL OPERATION

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Explain the two methods that are used to hold semi-floating axles in place.

2. Explain the advantage of using a hypoid gear in the differential.

3. Figure the following differential gear ratios:

	Ring gear teeth	Pinion gear teeth	Ratio
a	37	11	
b	37	12	
c	41	10	
d	34	15	

4. Two vehicles are being driven on level ground at 1500 rpm in high gear. The vehicles are identical with the exception that one has a differential ratio of 3.75 while the other has a differential ratio of 2.93. Identify which vehicle is moving faster and explain why.

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIFFERENTIAL OPERATION

(ANSWER SHEET)

1. A press-fit bearing and collar hold a retainer plate on the axle. The retainer plate is bolted to the flange on the end of the axle tube, and the C-lock fits into a machined grove at the inner end of the axle shaft. The C-lock holds the axle shaft in place by riding against the differential side gears.

2. Using a hypoid gear in the differential allows for a lower drive shaft line that results in a lower drive shaft tunnel. The lower the drive shaft tunnel, the more floorboard space in the passenger compartment.

3. a. 3.36 to 1
   b. 3.08 to 1
   c. 4.10 to 1
   d. 2.26 to 1

4. The vehicle with the 2.93 to 1 differential ratio is moving faster than the one with the 3.75 to 1 differential ratio. The ratio of input to output is closer to 1:1 in a 2.93 to 1 ratio than it is in a 3.75 to 1 ratio; therefore, the 2.93 to 1 ratio allows for more speed.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VII: DIFFERENTIAL COMPONENTS AND THEIR OPERATION

UNIT VII TEST

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. The bevel gear that meshes with the ring gear.

____ 2. A type of ring and drive pinion gear set in which the center line of the drive pinion gear is below the center line of the ring gear.

____ 3. A gear set in which the teeth of the drive pinion gear always engage the ring gear at a different point.

____ 4. A cone-shaped gear which meshes with a similarly beveled gear in order to change the angle between the driving and driven shafts.

____ 5. The two bevel gears that are splined to the axle ends within the bellhousing.

____ 6. The bevel gears which are located inside the differential case and which drive the axle side gears.

a. Axle side gears
b. Bevel gear
c. Brake backing plate
d. Differential pinion gears
e. Drive pinion gear
ab. Hunting gear
ac. Hypoid gear

SECTION B. **Select the best answer from the five choices listed.**

____ 7. An axle that neither supports vehicle weight nor holds the wheel to the vehicle is

a. the semi-floating axle.
b. the full-floating axle.
c. the three-quarter floating axle.
d. none of the above.
e. all of the above.

____ 8. An axle that both supports vehicle weight and holds the wheel to the vehicle is

a. the semi-floating axle.
b. the full-floating axle.
c. the three-quarter floating axle.
d. none of the above.
e. all of the above.

____ 9. An axle that holds the wheel on the vehicle, yet does not support vehicle weight is

a. the semi-floating axle.
b. the full-floating axle.
c. the three-quarter floating axle.
d. none of the above.
e. all of the above.

____ 10. A banjo housing is another term for

a. a third member differential housing.
b. an integral carrier differential housing.
c. a differential housing used in independent rear suspensions.
d. all of the above.
e. none of the above.

____ 11. A type of differential that is usually not removed from the vehicle for service is

a. the third-member differential.
b. the integral carrier differential.
c. the limited-slip differential.
d. all of the above.
e. none of the above.

____ 12. Some axles have a bearing that is pressed with great force onto the axle near the wheel hubs. A retainer plate holds this bearing (and axle shaft) in the housing. If this type of axle were to break inside the axle tube, the wheel would likely

a. come off the vehicle.
b. lean, yet remain on the vehicle.
c. neither lean nor come off the vehicle.
d. begin to wobble slightly.
e. do none of the above.

____ 13. If an axle using the C-lock assembly breaks, the wheel would likely

a. come off the vehicle.
b. lean, yet remain on the vehicle.
c. neither lean nor come off the vehicle.
d. begin to wobble slightly.
e. do none of the above.

____ 14. On semi-floating axles, the axle flange

a. is an integral part of the axle shaft.
b. is connected to the axle shaft by way of a tapered inner surface or splines.
c. is part of the hub and is held onto the axle housing tube with two large tapered roller bearings and a nut.
d. can be connected to the axle shaft by any of the above methods.
e. is connected to the axle shaft by none of the above methods.

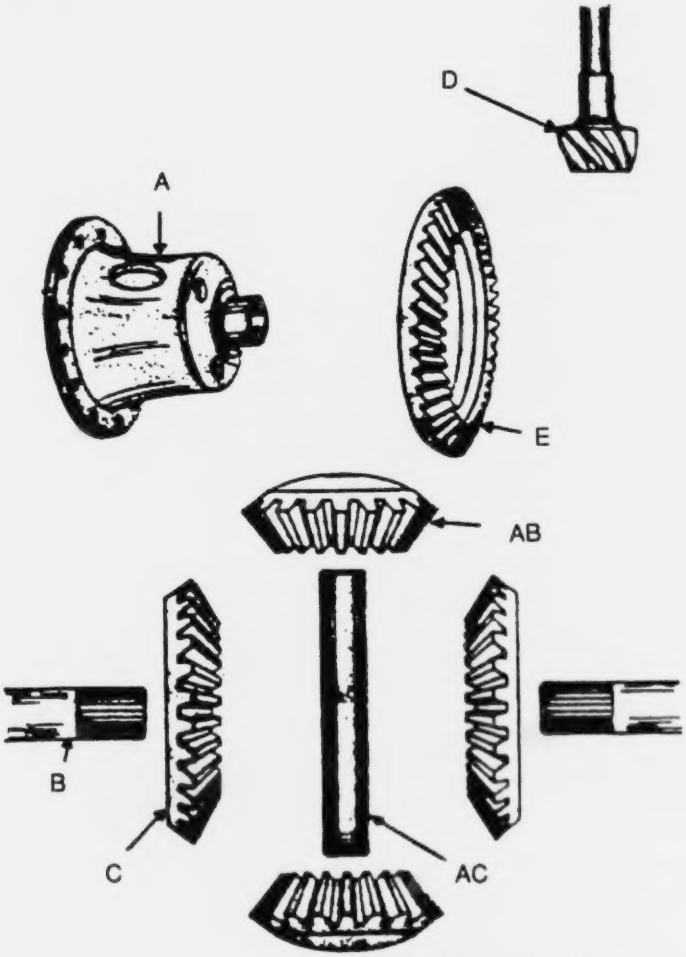
____ 15. On full-floating axles, the axle flange

a. is an integral part of the axle shaft.
b. is connected to the axle shaft by way of a tapered inner surface or splines.
c. is part of the hub and is held onto the axle housing tube with two large tapered roller bearings and a nut.
d. can be connected to the axle shaft by any of the above methods.
e. is connected to the axle shaft by none of the above methods.

____ 16. On three-quarter floating axles, the axle flange

a. is an integral part of the axle shaft.
b. is connected to the axle shaft by way of a tapered, inner surface or splines.
c. is part of the hub and is held onto the axle housing tube with two large tapered roller bearings and a nut.
d. can be connected to the axle shaft by any of the above methods.
e. is connected to the axle shaft by none of the above methods.

SECTION C. Shown below are several basic components of a differential. Place the letter of each component in the blank beside the component's name.



Reproduced by permission.
Crouse/Anglin AUTOMOTIVE MECHANICS.
9th ed. NewYork: McGraw-Hill Book Company, 1985.

____ 17. Ring gear

____ 18. Differential case

____ 19. Shaft

____ 20. Axle

____ 21. Drive pinion gear

____ 22. Differential side gear

____ 23. Pinion gear

SECTION D. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 24. The drive pinion gear transfers turning power from the axle to the differential.

____ 25. The drive pinion gear is connected to the rear U-joint by a companion flange, which is splined and bolted to the drive pinion gear.

____ 26. The ring gear engages the drive pinion gear and is turned at a right angle to it.

____ 27. Spur bevel gears are an improvement over the spiral bevel gears.

____ 28. In the hypoid gear design, the center line of the drive pinion gear is somewhat lower than the center line of the ring gear. The disadvantage of this design is that it allows for a higher drive shaft tunnel.

____ 29. The ring gear is bolted to the differential case.

____ 30. The differential case spins on outward-facing roller bearings called spinner bearings.

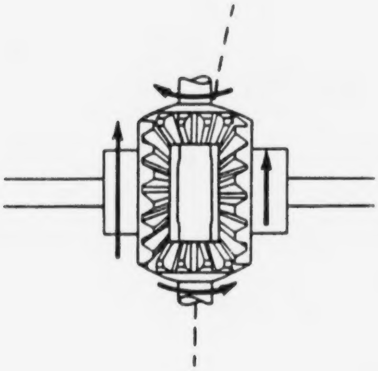
____ 31. Axle side gears are sometimes called spider gears.

____ 32. Axle side gears are spur bevel gears that mesh at a right angle with the differential pinion gears.

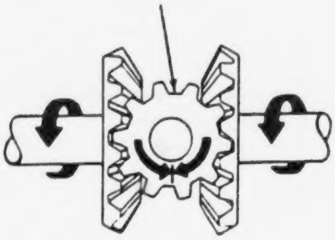
____ 33. Differential pinion gears deliver power to the axle side gears by moving end over end.

____ 34. Typical gear ratios for automobile differentials range from a high of approximately 2 to 1 to a low of about 4 to 1.

____ 35. Low gear ratios are necessary for vehicles with small tires.



____ 36. In the above illustration, arrows indicate the direction of forces acting upon a differential. The above illustration depicts a differential on a vehicle that is making a turn.



____ 37. In the above illustration, arrows indicate the direction of forces acting upon a differential. The above illustration depicts a differential on a vehicle that is making a turn.

____ 38. Differential gear lubricant should be of a heavy single viscosity such as 90 weight, or of a multiviscosity such as 80W85W90.

____ 39. Differential slip occurs when the two driving wheels on a vehicle turn in opposite directions.

____ 40. The differences between a limited-slip differential and a standard differential involve the construction and operation of the axle side gears.

(NOTE: The student must obtain a minimum score of _____ on the Unit VII Test in order to receive an evaluation for Competencies Cc1-Cc3.)

ANSWERS TO UNIT VII TEST

1. e
2. ac
3. ab
4. b
5. a
6. d
7. b
8. a
9. c
10. a
11. b
12. b
13. a
14. a
15. c
16. b
17. e
18. a
19. ac
20. b
21. d
22. c
23. ab
24. t
25. f
26. t
27. f
28. f
29. t
30. f
31. f
32. t
33. t
34. t
35. f
36. f
37. t
38. t
39. t
40. f

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose a differential and remove it from the vehicle. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student will be able to:

Lesson 1. I. Identify safety precautions for rear axle diagnosis and removal (Competency Cc1, Unit VIII Test).

II. Identify problems that do not require differential removal (Competency Cc1, Unit VIII Test).

III. Identify problems requiring differential removal (Competency Cc1, Unit VIII Test).

IV. Demonstrate the ability to:

a. Diagnose differential problems (Competency Cc1, JS1-L1-UVIII).

Lesson 2. I. Identify procedures for in-vehicle differential repairs (Competency Cc1, Unit VIII Test).

II. Identify procedures for differential removal (Competency Cc1, Unit VIII Test).

ASE TASKS COVERED IN THIS UNIT

I. The job sheet in this unit covers ASE tasks C051, C062, C066.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DIFFERENTIAL DIAGNOSIS

    a. Information outline

    b. Job sheets

      JS1-L1-UVIII: Differential Diagnosis

  2. Lesson 2: DIFFERENTIAL REPAIR

    a. Information outline

E. Unit test

F. Answers to unit test

REFERENCES

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Crouse, William H., and Donald L Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
   3. The Principles of the Differential (AM-84-450), 1984.
   4. Pinion Seal Replacement (AM-84-451), 1984.
   5. Axle Bearing and Seal Replacement (AM-84-452), 1984.
   6. Final Drive Adjustments (AM-84-453), 1984.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

LESSON 1: DIFFERENTIAL DIAGNOSIS

I. Safety in rear axle diagnosis and removal

  A. Test drive a vehicle only with approval of the instructor. Never drive a vehicle with the door open or attempt to listen underneath a vehicle while it is moving.

  B. Running engine while vehicle is on a hoist

    1. Raise hoist only when under the supervision of the instructor.

    2. Stay clear of hot exhaust system components. A catalytic converter can reach a temperature of over 1000°F. Wear protective clothing and gloves as required.

    3. Debris can fall from under a vehicle. Safety goggles must be worn when working under the vehicle.

    4. Hair and loose clothing can become entangled in moving drive train components. Secure hair and loose clothing. Stay clear of moving parts.

    5. Ventilate exhaust fumes to the outside.

    6. Never engage a vehicle's cruise control while the vehicle is on a hoist. (Always have another technician operate the vehicle while it is on a hoist.)

  C. Differential repair and removal

    1. The technician will often remove a vehicle's brake drums before working on the differential.

    (**CAUTION**: Do not breathe brake dust or blow it into the shop environment. Brake dust contains asbestos. Consult instructor for proper procedures.)

    2. Differential components are usually very heavy. Appropriate lifting equipment should be used when necessary. A technician should never bend his or her back when lifting a heavy object; instead, he or she should lift from the legs. Gloves should be worn to protect fingers from sharp edges if necessary.

II. Problems not requiring differential removal

  A. Noise

    1. A differential can be expected to produce some noise. A slight whine or growl is not uncommon at times.

(NOTE: Normal differential noise will be barely audible at some speeds. It is not unusual for such noise to occur when the transmission is under an extreme load or in reverse. Such noise tends to reach a peak at speeds of 40 to 60 mph.)

2. Road noise and tire noise will change as the vehicle travels over different surfaces. Over inflating tires temporarily (stay below 50 psi) often eliminates or reduces noise. Tire noise tends to change tone as speed increases. However, it does not vary much under "pull" and "coast" driving.

   (NOTE: Tire noise can be wrongly attributed to differential problems. The tires should be eliminated as a possible source of noise before attempting to service the differential.)

3. Front-wheel bearings can sometimes produce noise that is wrongly attributed to the differential. Check bearings for looseness and roughness by raising the front wheel off the ground and spinning it. Repair as required.

4. Vibration can be caused by drive shaft problems. Drive shaft problems can be mistaken for differential noise and chatter.

   (NOTE: Many engine and transmission noises are wrongly attributed to rear axle problems. If the noise is present while the vehicle is not moving, or if the noise varies with engine rpm and transmission gear range, check the engine and transmission.)

5. If gear lube in the transmission is too thin or contaminated, or if lubricant level is low, a whining sound can result. On limited-slip differentials, the incorrect type of lubricant can cause grabbing and chattering. Replace improper gear lube with the correct type and fill to the correct level.

B. Lubricant leaks

1. To repair a leaking inspection cover, replace gasket or cover as required. Gasket sealers are not used.

2. If gear lube is present in the rear brake assemblies, the axle bearing seal is defective and must be replaced. Wheel bearings should be inspected at this time for looseness or roughness.

3. Leakage at the companion flange area of the drive-pinion shaft indicates a defective drive pinion seal. The seal should be replaced and the drive pinion bearing should be inspected for damage.

III. Problems requiring differential removal

A. The differential housing is an extremely sturdy and durable component. If, however, it becomes cracked or bent, it must be replaced--a procedure that requires differential removal.

B. If differential pinions and side gears are damaged, they may produce noise when the vehicle makes tight turns. Repair of differential pinions and side gears will require differential removal.

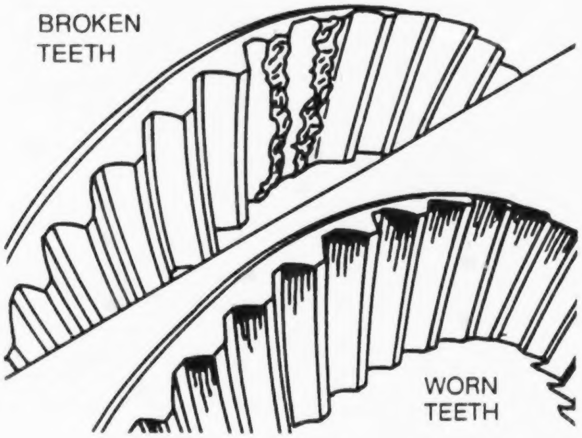
(NOTE: The differential pinion and side gears operate only when the vehicle is in a turn. These gears should, therefore, be inspected if the vehicle makes noise only during turns.)

C. Since the drive pinion shaft bearings spin faster than any other differential bearings (due to the final drive ratio), whining sounds begin at relatively low speeds and increase in pitch as vehicle speed increases. Repair will require differential removal.

D. Defective side bearings (or carrier bearings) will produce a constant, rough noise at a lower pitch than drive pinion shaft bearings. Repair will require differential removal.

E. Ring and drive pinion noise

   1. Worn or broken teeth on the ring or drive pinion gears produce very pronounced growling or clashing noises during all phases of vehicle operation. Repair will require differential removal and gear replacement.



Courtesy of Mitchell Information Services, Inc.

   2. Gear teeth meshing problems

      a. Improper meshing of gears produces a cycling pitch (whine) and will be very pronounced while the vehicle is "driving" or "coasting."

      (NOTE: "Driving" refers to vehicle acceleration or pulling. "Coasting" refers to gradual deceleration while the vehicle is in gear and the throttle is lifted.)

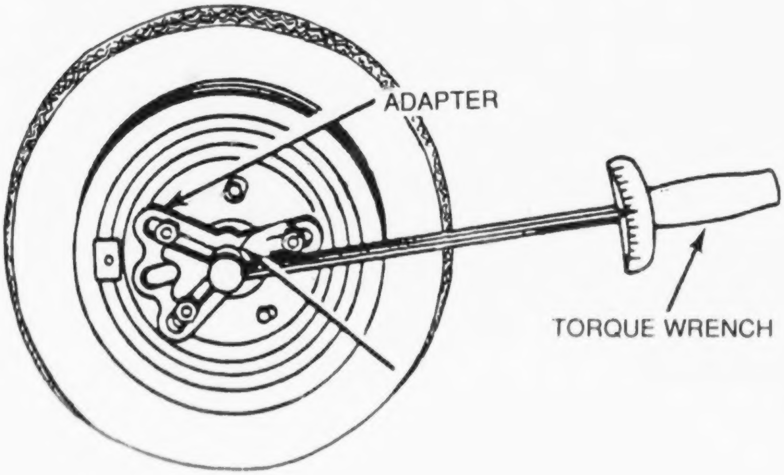
b. Meshing problems may also occur while vehicle is "floating."

(NOTE: Floating occurs when just enough throttle pressure is applied to maintain vehicle speed.)

(NOTE: Gear mesh noise tends to peak in a narrow speed range while remaining constant in pitch. Bearing noise, on the other hand, varies in pitch with changes in vehicle speed. Repair of these problems will require differential removal.)

F. If the clutch system in a limited-slip differential becomes worn, a loss of limited-slip action will occur. Repair will require differential removal. The clutch can be checked by using the following procedure.

1. Put the transmission in gear (put automatic transmissions in park) and raise both rear wheels off the ground.
2. Using an appropriate adaptor, connect a torque wrench to the wheel lugs.
3. Measure the torque required to rotate one wheel.
4. Compare torque measurements with factory specifications. If torque measurements are less than specified, the limited-slip assembly must be overhauled.



JS1-L1-UVIII

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIFFERENTIAL DIAGNOSIS

Equipment:

Hoist
Safety glasses
Service light

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, performance test a differential assembly: ___ ___ ___ ___

   a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, clanking, or other unusual noise or activity.

   b. Drive vehicle slowly in reverse and note any grinding, clanking, or other unusual activity.

   c. Record results of the performance test.

3. Place the vehicle securely on safety stands or lift it with a hoist. ___ ___ ___ ___

4. Following the procedure outlined below, diagnose differential assembly problems. ___ ___ ___ ___

   a. Inspect the differential for leaks. Record observations.

   b. Inspect the differential mounts for looseness. Record observations.

c. Inspect the differential control arms for looseness (rear-wheel-drive vehicles). Record observations.

d. Rotate the drive shaft back and forth while observing the movement between the pinion shaft and the tires. Record observations.

e. According to this series of checks, the differential assembly is:

OK _____ Not OK _____

f. If differential assembly is not OK, recommend steps to correct the problem.

Average of above evaluations* — — — —

(*This is the final evaluation for Competency Cc1.)

MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

LESSON 2: DIFFERENTIAL REPAIR

I. In-vehicle differential repairs

A. Procedure for rear-wheel bearing and seal replacement (semi-floating press fit bearing types)

1. Place the car securely on safety stands or lift with hoist. Refer to manufacturer's recommendations for correct jackstand or lift locations.

2. Remove rear wheels.

3. Remove brake drums.

   (**CAUTION**: Do not breathe brake dust or blow it into the shop environment. Brake dust contains asbestos. Consult instructor for proper procedures.)

4. Remove axle bearing retainer plate. Bolts are accessible through a hole in the wheel flange. Some vehicles may require that the brake lines and backing plate assembly be removed. Refer to a service manual for correct procedures.

5. Pull axle shaft from differential. A slide-hammer may be required to remove the axle.

6. Split the retainer with a chisel.

7. Press old bearing, collar, seal, and retainer plate off axle with hydraulic press and appropriate fixtures.

8. Clean and inspect axle shaft for damaged journal surface or bending.

9. Slip retainer plate, seal, bearing, and collar over axle shaft and press into position with hydraulic press and appropriate fixtures.

10. Install axle assembly into differential.

11. Tighten retainer plate and bolts to correct torque specification. Reconnect brake lines and bleed the brakes if required.

12. Inspect brakes, adjust shoes, and install brake drums.

13. Install rear wheels and torque lugs. Bleed brake lines if they were previously removed.

14. Check and adjust differential fluid level and fill the brake fluid to the proper level.

B. Procedure for replacing rear-wheel bearings and seals (semi-floating C-lock type)

1. Place the car securely on safety stands or lift with hoist. Refer to manufacturer's recommendations for correct jackstand or lift locations.

2. Remove rear wheels.

3. Position oil drain pan under center section of differential. Remove inspection cover and allow lubricant to drain into pan.

4. Remove brake drums.

   (**CAUTION**: Do not breathe brake dust or blow it into the shop environment. Brake dust contains asbestos. Consult instructor for proper procedures.)

5. Rotate differential case until the differential pinion shaft retaining bolt is accessible. Remove bolt.

6. Slip differential pinion shaft out just far enough to push inward on axle shafts and expose C-locks from recess in side gears. Remove C-locks.

7. Slide axle shafts out of differential.

8. Pull seals and axle bearings from differential housing with appropriate puller.

9. Install new bearings and seals.

10. Clean and inspect axle shaft for bends or damaged bearing journal surface. Replace shaft as required.

11. Slide axle shaft into differential. Be sure to reposition side gear in differential case.

12. Install C-lock and pull outward on axle shaft. Doing so will seat C-lock into recess in side gear within differential case.

13. Slide pinion shaft through case and pinion gears.

14. Install differential pinion shaft retainer bolt and tighten to specification.

    (NOTE: Refer to the manufacturer's specifications for the exact torque.)

15. Install inspection cover and new gasket. Tighten to specifications.

16. Inspect and adjust brakes. Install brake drums.

17. Install wheels and torque lugs to specifications.

18. Remove fill plug in differential center section and fill to level with correct gear lubricant. Replace fill plug.

C. The procedure for replacing three-quarter floating and full-floating rear-wheel bearings and seals varies widely, depending on vehicle model. Refer to manual for correct procedures.

D. Procedure for replacing drive pinion seal

1. Place the car securely on safety stands or lift with hoist. Refer to manufacturer's recommendations for correct jackstand or lift locations.

2. Remove rear wheels.

3. Remove brake drums.

   (CAUTION: Do not breathe brake dust or blow it into the shop environment. Brake dust contains asbestos. Consult instructor for proper procedures.)

4. Remove drive shaft. Slip an old drive shaft yoke or rag into transmission extension housing to prevent lubricant loss.

5. Using an inch lb. torque wrench, measure and record torque required to turn pinion through several revolutions.

6. Make witness marks on companion flange and pinion shaft so that flange can be returned to the same position.

7. Remove pinion nut.

   (NOTE: The pinion nut is very difficult to loosen and tighten. Consult the instructor for the best procedure.)

8. Remove flange. Use an appropriate puller.

9. Pry seal out of housing.

10. Install new seal. If seal becomes cocked during installation, replace it with a new one.

11. Install companion flange with witness marks in alignment. Install pinion nut.

    (NOTE: Most manufacturers recommend that a new nut be used. Refer to the manual for correct procedure.)

12. Gradually tighten pinion nut while periodically checking turning torque with inch lb. torque wrench. Nut should be tightened until original turning torque (which should have been recorded earlier) is reached. Do not exceed torque specification.

    (NOTE: The pinion nut is very difficult to loosen and tighten. Consult the instructor for the best procedure.)

13. Remove yoke or rag from transmission and install drive shaft.

14. Remove fill plug in differential center section and fill to level with correct gear lubricant. Replace fill plug.

II. Differential removal

A. Procedure for removing integral carrier differentials

1. Place the car securely on safety stands or lift with hoist. The rear of the vehicle must be supported by the frame. Refer to manufacturer's recommendations for correct jackstand or lift locations.

2. Disconnect all brake lines, parking brake cables, and other wires from the differential.

3. Remove wheels.

4. Remove the drive shaft. Slip an old drive shaft yoke or rag into the transmission extension housing to prevent lubricant loss.

5. Raise differential slightly to relieve tension on shock absorbers. Disconnect shock absorbers at the bottom.

6. Lower differential and remove coil springs. On leaf-spring vehicles, remove U-bolts and rear shackles.

7. Disconnect control arms (on coil spring vehicles) and lower differential from vehicle.

   (**CAUTION:** The differential can weigh over a hundred pounds. Be extremely careful not to drop the differential.)

B. Procedure for removing third member (removable carrier) differentials

1. Place the car securely on safety stands or lift with hoist. Refer to manufacturer's recommendations for correct jackstand or lift locations.

2. Remove wheels.

3. Disconnect all brake lines and parking brake cables from differential center section only.

4. Remove drive shaft. Slip an old drive shaft yoke or rag into the transmission extension housing to prevent lubricant loss.

5. Remove brake drums.

   (**CAUTION:** Do not breathe brake dust or blow it into the shop environment. Brake dust contains asbestos. Consult the instructor for proper procedures.)

6. Remove axle bearing retainer plates. Pull axle shafts from differential. A slide-hammer may be required.

7. Position oil drain under center section.

8. Support third member (removable carrier) and remove nuts around its perimeter.

(**CAUTION:** Be extremely careful not to drop the differential. The differential can weigh over 100 pounds.)

9. Split housing and remove third member. Additional gear lube may pour from the differential.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT VIII: DIFFERENTIAL DIAGNOSIS AND REMOVAL

UNIT VIII TEST

SECTION A. Select the best answer from the five choices listed.

____ 1. A dangerous substance found in brake drums is

- a. bakelite.
- b. sulfate.
- c. alkaloid.
- d. ammonia.
- e. asbestos.

____ 2. Worn or broken teeth on the ring and drive pinion gears produce very pronounced growling or clashing noises

- a. only when vehicle is in a low gear.
- b. only when vehicle is in a high gear.
- c. only when vehicle is in reverse.
- d. during all phases of vehicle operation.
- e. during acceleration only.

____ 3. Improper meshing of gears produces

- a. a cycling pitch (whine), which will be very pronounced while the vehicle is "driving" or "coasting."
- b. a loud, persistent banging, which will be very pronounced while the vehicle is "driving" or "coasting."
- c. black smoke, which will become thicker while the vehicle is "driving" or "coasting."
- d. sparks, which will become more visible while the vehicle is "driving" or "coasting."
- e. none of the above.

____ 4. When used in a discussion of improper gear meshing, the term "driving" refers to

- a. gradual deceleration while the vehicle is in gear and the throttle is lifted.
- b. the application of just enough throttle to keep the vehicle from slowing the engine.
- c. abrupt deceleration caused by brake application.
- d. abrupt deceleration caused by shifting from a high gear to a low gear.
- e. vehicle acceleration or pulling.

____ 5. When used in a discussion of improper gear meshing, the term "coasting" refers to

a. gradual deceleration while the vehicle is in gear and the throttle is lifted.
b. the application of just enough throttle to keep the vehicle from slowing the engine.
c. abrupt deceleration caused by brake application.
d. abrupt deceleration caused by shifting from a high gear to a low gear.
e. vehicle acceleration or pulling.

____ 6. When used in a discussion of improper gear meshing, the term "floating" refers to

a. gradual deceleration while the vehicle is in gear and the throttle is lifted.
b. the application of just enough throttle to keep the vehicle from slowing the engine.
c. abrupt deceleration caused by applying the brakes.
d. abrupt deceleration caused by shifting from a high gear to a low gear.
e. vehicle acceleration or pulling.

____ 7. Gear mesh noise tends to

a. vary in pitch regardless of vehicle speed.
b. vary in pitch in relation to vehicle speed.
c. remain constant in pitch.
d. occur only when vehicle is in reverse.
e. occur only when vehicle is in a low gear.

____ 8. Bearing noise tends to

a. vary in pitch regardless of vehicle speed.
b. vary in pitch in relation to vehicle speed.
c. remain constant in pitch.
d. occur only when vehicle is in reverse.
e. occur only when vehicle is in a low gear.

SECTION B. **Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.**

____ 9. It is normal for some transmission noise to occur when the transmission is under an extreme load or in reverse. These "normal" noises tend to reach a peak at speeds over 20 mph.

____ 10. Over inflating tires temporarily often eliminates or reduces tire noise.

____ 11. Tire noise tends to change in quality when the vehicle switches from "pull" to "coast" driving.

____ 12. Tire noise can easily be mistaken for differential noise.

____ 13. Front-wheel bearings can sometimes produce noise that can be mistaken for differential problems.

____ 14. Bearings can be checked for looseness and roughness with a feeler gauge.

____ 15. Most vehicle vibration is caused by chaise problems and can easily be wrongly attributed to differential noise.

____ 16. On limited-slip differentials, the incorrect type of lubricant can cause grabbing and chattering.

____ 17. To repair a leaking inspection cover, the technician may have to replace the gasket.

____ 18. If gear lube is present in the rear brake assemblies, the bearing retainer ring is defective and must be replaced.

____ 19. Leakage at the companion flange area indicates a defective drive pinion seal.

____ 20. Differential pinion and side gear damage is unusual since these gears operate only while the vehicle is in a turn.

____ 21. Part of the procedure for checking the clutch system in a limited-slip differential involves measuring the torque required to rotate one wheel.

____ 22. A hydraulic press may be required to remove an axle from a differential.

____ 23. When replacing a drive pinion seal, the technician should use an inch lb. torque wrench to measure and record torque required to turn the pinion through several revolutions.

____ 24. Though all other wires should be disconnected from the differential when it is removed from the vehicle, the technician should make sure the parking brake cables remain connected.

____ 25. When removing a differential, the technician should slip an old drive shaft yoke or rag into the transmission extension housing to prevent lubricant loss.

(NOTE: The student must obtain a minimum score of ____ on the Unit VIII Test in order to receive an evaluation for Competency Cc1.)

ANSWERS TO UNIT VIII TEST

1. e
2. d
3. a
4. e
5. a
6. b
7. c
8. b
9. f
10. t
11. f
12. t
13. t
14. f
15. f
16. t
17. t
18. f
19. t
20. t
21. t
22. f
23. t
24. f
25. t

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IX: DIFFERENTIAL REPAIR, INSTALLATION, AND PERFORMANCE TESTING

UNIT OBJECTIVE

After completing this unit, the student should be able to disassemble, repair, reassemble, and adjust a differential. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms associated with differential service (Competency Cc2, Part I of the Unit IX Test).

II. Identify procedures for differential disassembly (Competency Cc2, Part I of the Unit IX Test).

III. Identify procedures for cleaning and inspecting a differential (Competency Cc2, Part I of the Unit IX Test).

Lesson 2. I. Identify procedures for differential assembly and adjustment (Competency Cc3, Part II of the Unit IX Test).

II. Identify procedures for differential installation (Competency Cc3, Part II of the Unit IX Test).

III. Identify methods for performance testing the differential (Competency Cc3, Part II of the Unit IX Test).

IV. Demonstrate the ability to:

a. Service a differential (Competencies Cc2 and Cc3, JS1-L2-UIX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheet in this unit covers ASE tasks C052-C061, C063, C064, and C067-C071.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IX: DIFFERENTIAL REPAIR, INSTALLATION, AND PERFORMANCE TESTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DIFFERENTIAL DISASSEMBLY, CLEANING, AND INSPECTION

    a. Information outline

  2. Lesson 2: DIFFERENTIAL ASSEMBLY, ADJUSTMENT, INSTALLATION, AND PERFORMANCE TESTING

    a. Information outline

    b. Assignment sheets

      AS1-L2-UIX: Differential Removal and Reinstallation

      AS2-L2-UIX: Differential Service Procedure

    c. Job sheets

      JS1-L2-UIX: Servicing a Differential

E. Unit test

F. Answers to unit test

REFERENCES

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Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI. Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UIX and AS2-L2-UIX in conjunction with JS1-L2-UIX.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
   3. The Principles of the Differential (AM-84-450), 1984.
   4. Pinion Seal Replacement (AM-84-451), 1984.
   5. Axle Bearing and Seal Replacement (AM-84-452), 1984.
   6. Final Drive Adjustments (AM-84-453), 1984.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IX: DIFFERENTIAL REPAIR, INSTALLATION, AND PERFORMANCE TESTING

LESSON 1: DIFFERENTIAL DISASSEMBLY, CLEANING, AND INSPECTION

I. Terms and definitions

A. Backlash--The distance that one gear can be rotated without moving the gear to which it is engaged.

B. Dial indicator--A precision measuring instrument which indicates the amount of movement of a spring-loaded plunger on a graduated dial scale.

C. Face (gear tooth)--The upper side surface of a gear tooth.

D. Flank (gear tooth)--The lower side surface of a gear tooth.

E. Heel (gear tooth)--The wider outer surface of a gear tooth.

F. Pitch line (gear tooth)--The center of the side surface of a gear tooth. This line divides the side of the gear tooth into the face and flank.

G. Preload--A slight amount of tension or pressure on a bearing. This pressure is applied during assembly to compensate for stretching or wear during operation.

H. Spanner wrench--A wrench with fingers, which are inserted into holes drilled into a specially designed nut.

I. Toes (gear tooth)--The narrow inner surface of a tapered gear tooth.

J. Witness marks--Punch marks applied to a component by a technician. Witness marks allow the technician to replace the component in the correct position.

II. Procedure for differential disassembly

A. Remove the third member, if required.

B. Remove inspection cover and axle shafts (integral carrier differentials only).

C. Scribe or punch witness marks into the companion flange, the drive pinion shaft, and the nut. The marks will ensure that the components are replaced in the proper position.

D. Remove carrier bearing cap bolts and caps.

(NOTE: Mark caps to indicate the position to which they should be returned during reassembly.)

E. Remove differential case assembly. On some differentials, assembly removal requires the use of a case spreader.

F. Remove ring gear and shims from case.

G. Remove differential pinion shaft retaining bolts and slip out shaft.

H. Remove differential pinion gears and shim washers.

(NOTE: Keep parts together for reassembly.)

I. Remove axle side gears and shim washers or clutch plates.

(NOTE: Keep parts in order for reassembly.)

J. If carrier bearings are to be replaced, pull them off the flanges with a suitable puller. Tag all shims to ensure that they are replaced in the correct location.

K. Remove drive pinion nut. Pull companion flange off with a suitable puller.

L. Remove drive pinion gear from housing.

M. To remove seal, shim pack (if used), and races, use appropriate driving tools. Tag all shims to ensure they are replaced in the correct location.

III. Procedures for cleaning and inspecting a differential

A. Remove gasket material from housing and inspection cover or third member.

B. Use a suitable solvent to wash all differential components and housing.

C. Inspect all bearings and races for roughness or wear.

(NOTE: Wear will be most evident at the large end of tapered roller bearings.)

D. Inspect all axle splines for wear.

E. Inspect ring gear and pinion teeth for possible scorching, cracking, or chipping.

F. Inspect differential pinion gears and axle side gears for wear. Inspect shim washers for wear or burning. Inspect clutches for wear on limited-slip differentials.

G. Inspect differential pinion shaft for wear.

H. Replace all parts as required.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IX: DIFFERENTIAL REPAIR, INSTALLATION, AND PERFORMANCE TESTING

LESSON 2: DIFFERENTIAL ASSEMBLY, ADJUSTMENT, INSTALLATION, AND PERFORMANCE TESTING

I. Differential assembly and adjustment

A. Drive pinion depth measurement

1. The mesh of the ring and drive pinion gears and bearing preload is critical. Therefore, normal manufacturing tolerances require that certain measurements and adjustments be made. Drive pinion gear depth directly affects gear mesh. Adjustment of drive pinion gear depth should, therefore, be one of the first procedures performed during differential reassembly.

2. Special tool kits are necessary to make the drive pinion depth adjustment. Refer to the manual for the required tools and procedures.

3. Adjustment of drive pinion depth is accomplished by installing special shims following measurement.

B. Procedure for adjusting the drive pinion gear according to factory measurement

1. The drive pinion gear is measured and marked at the time of manufacture. A measurement in thousandths of an inch will be stamped on the gear and/or shaft.

2. If the measurement stamped on the gear is negative, add that many thousandths of an inch worth of shims to the shim pack. If the measurement is positive, subtract that many thousandths of an inch worth of shims from the shim pack.

(NOTE: In the above procedure, measurements are added and subtracted because the stamped number indicates whether the gear was made bigger [in which case the number is positive] or smaller [in which case the number is negative] than the exact intended measurement. The technician must compensate for a gear that is too big by removing the exact amount of shims from the shim pack. Conversely, the technician must compensate for a gear that is too small by adding the exact amount of shims. If the gear measured exactly the correct size, a "0" would be stamped on it.)

C. Alternate methods for taking drive pinion depth measurements

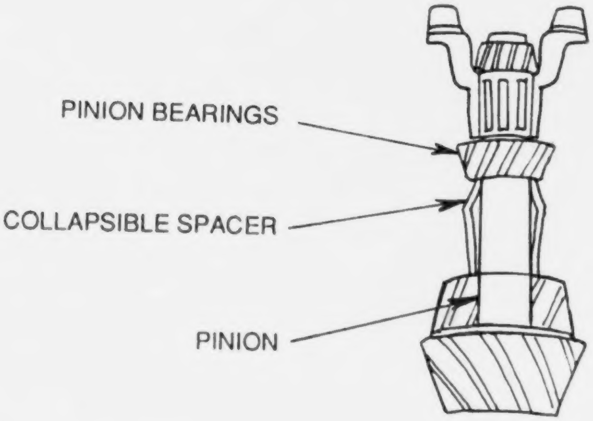
1. Some drive pinion depth measurements are made by installing a gauge block kit into the differential-carrier bearing bores. After torquing the gauge block kit into the bearing bores, use a feeler gauge to measure the gap to be taken up with the shim pack. The final shim pack should pass between the gauge block and a gauge tube with slight drag.

2. Another method of achieving the correct drive pinion depth is to compare the depth marking on the old gear with the one on the new gear (on marked drive pinion gears). If, for instance, the old drive pinion gear was marked +3 (meaning that three thousandths of an inch was subtracted from the shim pack at the time of assembly) and the new gear is marked -2 (meaning two thousandths of an inch will need to be added to the shim pack), the technician can calculate the required shim adjustment without making the drive pinion depth measurement. Adding three thousandths of an inch (.003 in.) would bring the shim pack back to "0", at which time two thousandths of an inch more thickness (.002 in.) will have to be added to accommodate the new gear (which was too small by .002 in.). Three thousandths of an inch plus an additional two thousandths of an inch comes to a total of five thousandths of an inch (.005 in.), which must be added to the old shim pack.

D. Adjusting pinion bearing preload

1. Drive pinion gears operate on a pair of inward-facing, tapered roller bearings. The clearance between these bearings and their races is critical. Normal manufacturing tolerance differences require that this clearance adjustment, called bearing preload, be made for new drive pinion gears at the time of assembly.

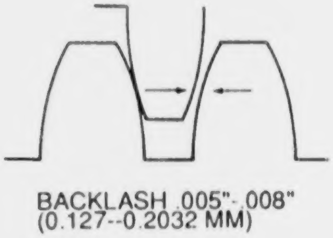
2. Most manufacturers use a collapsible spacer between the drive pinion bearings. As the drive pinion bearing nut is tightened against the companion flange, the flange presses against the race of the outer pinion bearing. The outer race presses against the inner race of the inner pinion bearing. Since the inner pinion bearing race is up against the drive pinion gear, inner pinion bearing race cannot move. Additional pressure resulting from the tightening of the nut begins to collapse the spacer and increase bearing preload. Until the necessary turning torque specification is reached, it is extremely important to check the turning torque frequently with an inch lb. torque wrench. If the spacer has been collapsed too far, it must be replaced with a new one.

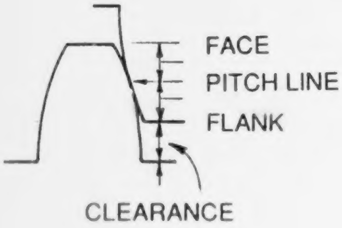


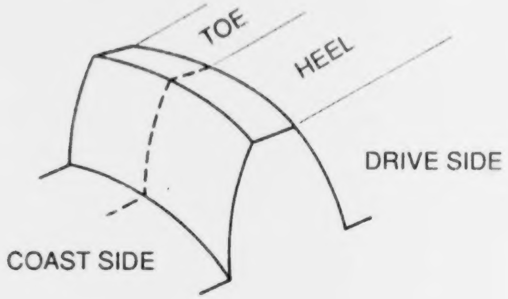
E. Procedure for installing the drive-pinion shaft

1. Lubricate the drive pinion bearing races and seal with gear lube. Install races with the shim pack in the differential housing.
2. Install the bearing on the drive pinion gear (if previously removed) along with the shim.
3. Lubricate the bearings and install the drive pinion assembly into the differential housing.
4. Lubricate and install the outer drive pinion bearing, the companion flange (with guard), the washer, and the nut.
5. Tighten the nut and periodically check turning torque. If the torque specification for the pinion nut is reached before the turning torque specification for the pinion shaft is reached, replace the spacer. Stop tightening nut when correct turning torque is reached. Do not over tighten.

F. Gear tooth terminology







1. Toe--The narrow, inner surface of the tapered tooth of a ring gear.
2. Heel--The wider, outer surface of the tapered tooth of a ring gear.

3. Pitch line--The center of the side surface of a ring gear tooth. The pitch line divides the side surface of the tooth into the face and flank.

4. Face--The upper side surface of a ring gear tooth.

5. Flank--The lower side surface of a ring gear tooth.

6. Drive side--The side of the ring gear tooth that is in contact with the drive pinion gear tooth while the engine is applying torque to the differential. The drive side is somewhat convex (bulging outward) in shape.

7. Coast side--The side of the ring gear tooth that is in contact with the drive pinion gear tooth while the vehicle is decelerating as a result of the differential slowing the driveline and engine. The coast side of the tooth is somewhat concave (sloping inward) in shape.

8. Backlash--The distance that the ring gear can be rotated back and forth without turning the drive pinion gear.

G. Procedure for adjusting backlash

1. Install the carrier bearings on the differential case along with the proper shim pack.

2. Install the ring gear on the differential case along with any spacers. Gradually tighten bolts to proper torque specification.

   (NOTE: Ring and drive pinion gears must always be installed as a matched set. The gear ratio will establish the size and number of teeth. Due to manufacturing tolerances, gears must be specially machined and run in together at the time of manufacture.)

3. Install the differential case and ring gear assembly into the housing along with carrier-bearing- adjustment hardware or shims.

   (NOTE: Nonhunting ring and pinion gears have timing marks, which must be aligned as the gears are meshed during case installation. This alignment is essential because it ensures that tooth contact will be the same as when the gears were run in. Refer to manual to determine if the vehicle being serviced has a nonhunting gear set. Hunting gear sets require no such alignment.)

4. Adjust case side play. Procedures for this adjustment vary from manufacturer to manufacturer. Refer to manual for correct procedure.

5. Install carrier bearing caps and bolts (if not previously required). Tighten shim-adjusted differential cases to specification.

   (NOTE: Cases with spanner adjusters should be only slightly tightened--usually to about 10 ft. lbs. Refer to manual for exact specifications.)

6. Attach dial indicator so that plunger contacts outer edge of ring gear tooth. Move ring gear back and forth and record the backlash reading given by the dial indicator.

(NOTE: The drive pinion gear must not rotate during this measurement. Adjust backlash to specification. Refer to manual for correct procedure and specifications.)

7. When correct backlash measurement is achieved, remove dial indicator and make any required final bolt torquing and measurements.

H. Procedure for checking gear tooth contact pattern

1. Apply suitable marking grease to the ring gear teeth.

2. Rotate drive pinion gear (two or three revolutions should be adequate) until a good pattern is visible on the marking grease. Apply resistance to ring gear with hand.

3. The contact pattern should show an oval area of contact in the middle of the ring gear tooth.

4. Check both drive and coast patterns. The pinion gear is moved by using different shim thicknesses. The ring gear is moved by using different shims or by rotating adjusters with a spanner wrench.

I. Procedure for checking axle side gear clearance

1. Install the side gears with the shim washers. Install axles and C-locks if required.

2. Install the differential pinion gears and shim washers.

3. Slip the differential pinion shaft through the case and gears.

4. Install and tighten the differential pinion shaft retaining bolt.

5. Check axle side gear clearance by inserting two feeler gauges between the differential case and side gear shim washers.

6. Compare measurement with factory specification and adjust as necessary. Adjustment is accomplished by using different thicknesses of side gear shim washers.

J. Procedures for completing differential assembly

1. Install third member in housing (if required) with new gasket. Tighten bolts or nuts gradually to correct torque specification.

2. Install inspection cover and new gasket (if required).

3. Install axles (if not done previously).

II. Differential installation

A. Procedures for installing integral carrier differential assembly

1. Raise differential into position under vehicle.

2. Connect control arms and tighten bolts. On leaf-spring vehicles, place housing on springs with axle tube pad holes engaging spring center bolt. Install U-bolts, shock plates, and nuts. Tighten nuts evenly to specification.

3. Install coil spring (on vehicles so equipped) with spring end properly aligned with spring pockets. On leaf-spring vehicles, attach and tighten rear shackles.

4. Raise differential until shock absorber can be installed. Tighten shock absorber.

5. Inspect and adjust brakes. Install brake drums.

6. Reconnect brake lines, parking brake cables, and any other wires that were previously removed.

7. Remove old yoke or rag from transmission and install drive shaft.

8. Attach wheels.

9. Add the correct amount of gear lubricant.

10. Bleed rear brake lines and refill brake fluid in master cylinder.

B. Procedure for aligning drive shaft

(NOTE: The differential alignment should be checked to ensure that the rear U-joint is not operated at an excessive angle, which would result in premature failure or nonconstant-velocity vibrations. Measurement must be made with special measuring tools called inclinometers.)

1. Remove all dirt from U-joint bearing caps and place inclinometer on rear U-joint bearing cap. The drive shaft must be turned so that one differential cap is pointing straight down.

2. Center sight glass bubble and record reading.

3. Remove inclinometer and rotate drive shaft 90°.

4. Place inclinometer on the drive-shaft-side U-joint cap and measure angle.

5. Subtract the two readings to determine the rear U-joint angle.

6. Refer to manufacturer's specification and adjustment procedure. Adjustment may be made by repositioning control arms, using shorter or longer control arms, or using shims.

   (NOTE: The same measurement can be made at the front U-joint. Refer to manufacturer's specification. Adjustments are made by adding shims to the transmission mount.)

II. Differential performance testing

A. Following differential installation and adjustment, the technician should conduct a performance test. The vehicle should be driven normally at highway speeds. Any unusual vibrations or noises should be noted. Refer to the trouble diagnosis chart for symptoms and causes. Check underneath the vehicle for lubricant or brake fluid leakage.

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIFFERENTIAL REMOVAL AND REINSTALLATION

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the differential assembly from the vehicle.
3. Develop a written procedure for reinstalling the differential assembly in the vehicle.

(NOTE: Be sure to include all torque specifications in the procedure. Also be sure to include the procedure for bleeding the brakes if the brake hydraulic system is open.)

MODULE: MANUAL DRIVE TRAINS AND AXLES

DIFFERENTIAL SERVICE PROCEDURE

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. List each procedure to be performed on the differential.

3. Develop a written procedure for each of the procedures listed in item 2 above. (The following are examples of specific procedures: replacing the axle bearing; changing the pinion seal; and replacing the ring and pinion gear set.)

   (NOTE: Be sure to include all torque specifications and adjustment specifications in the procedure. Also include such steps as disassembly, clean up, inspection, reassembly, and adjustment.)

JS1-L2-UIX

MODULE: MANUAL DRIVE TRAINS AND AXLES

SERVICING A DIFFERENTIAL

Equipment:

Hoist
Drain pan
Service light
Vise
Hand tools
Torque wrench
Feeler gauge
Ring and pinion depth gauge
Dial indicator
Jack
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, determine differential service procedure. ___ ___ ___ ___

   a. Complete JS1-L1-UVIII.

   b. Check the type of differential assembly to be serviced.

      Removable carrier ______________

      Integral carrier ______________

   c. Does the differential need to be removed from the vehicle?

      Yes ______ No ______

   d. If yes, complete AS1-L2-UIX, Differential Removal and Reinstallation.

   e. Complete AS2-L2-UIX.

3. Following the procedure outlined below, service a differential. ___ ___ ___ ___

   a. Place the car securely on safety stands or lift with hoist.

   b. Using the procedure developed in AS1-L2-UIX, remove the differential assembly, if required.

c. Complete AS2-L2-UIX.

d. Using the procedure developed in AS2-L2-UIX, service the differential assembly.

e. Using the procedure developed in AS1-L2-UIX, reinstall the differential.

f. Fill the differential assembly with the lubricant recommended by the manufacturer. Fill to the correct level.

g. Rotate drive shaft (attached to pinion shaft) to confirm that the differential assembly and wheels work freely.

4. Following the procedure outlined below, performance test the differential assembly. _ _ _ _

a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, clanking, or other unusual noise or activity.

b. Drive vehicle slowly in reverse and note any grinding, clanking, or other unusual noise or activity.

c. Record results of performance test.

Average of above evaluations

_ _ _ _

(*This average is the final evaluation for Competencies Cc2 and Cc3.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT IX: DIFFERENTIAL REPAIR, INSTALLATION, AND PERFORMANCE TESTING

UNIT IX TEST

PART I. DISASSEMBLING, CLEANING, AND INSPECTING THE DIFFERENTIAL

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. The upper side surface of a gear tooth.

____ 2. The wider outer surface of a gear tooth.

____ 3. The lower side surface of a gear tooth.

____ 4. The amount that one gear can be moved without moving the gear to which it is engaged.

____ 5. The narrow inner surface of a tapered gear tooth.

____ 6. A precision measuring instrument that indicates the amount of movement of a spring-loaded plunger on a graduated dial scale.

____ 7. A slight amount of tension or pressure on a bearing. This pressure is applied during assembly to compensate for stretching or wear during operation.

a. Backlash

b. Dial indicator

c. Face (gear tooth)

d. Flank (gear tooth)

e. Heel (gear tooth)

ab. Preload

ac. Spanner wrench

ad. Toes (gear tooth)

SECTION B. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 8. Technician I says that witness marks should be made either with chalk or a grease pencil.

Technician II says that carrier differentials are the only ones that require the removal of the inspection cover and axle shafts during disassembly.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 9. Technician I says that a case spreader is not required to remove all types of differential case assemblies.

Technician II says that carrier bearings can be pulled off the differential case if they are to be replaced with a suitable puller.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 10. Technician I says that either a wire brush or steel wool should be used to clean differential components.

Technician II says that wear will be most evident at the small end of tapered roller bearings.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 11. Technician I says that, if one spline on a differential is in good condition, the others will be in good condition as well.

Technician II says that, regardless of their apparent condition, clutches on limited-slip differentials should be routinely replaced.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 12. Technician I says that shim washers should be inspected for wear or burning.

Technician II says that, if the differential pinion gears are in good condition, the axle side gears will be in good condition as well.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on Part I of the Unit IX Test in order to receive an evaluation for Competency Cc2.)

PART II. ASSEMBLING, ADJUSTING, INSTALLING, AND PERFORMANCE TESTING A DIFFERENTIAL

SECTION A. Select the best answer from the five choices listed.

____ 13. Drive pinion depth will affect

a. gear size.
b. the number of gear teeth.
c. gear mesh.
d. all of the above.
e. none of the above.

____ 14. The measurement that is stamped on the pinion gear is also stamped on

a. the differential housing.
b. the ring gear.
c. the bearing retainer.
d. the differential side gears.
e. none of the above.

____ 15. When adjusting the drive pinion gear, the technician must take note of the measurement stamped on the gear. If the measurement is negative, the technician should

a. add that many thousandths of an inch worth of shims to the shim pack.
b. subtract that many thousandths of an inch worth of shims from the shim pack.
c. multiply the measurement by 2 and add that many thousandths of an inch worth of shims to the shim pack.
d. multiply the measurement by 3 and add that many thousandths of an inch worth of shims to the shim pack.
e. do none of the above.

____ 16. Some drive pinion depth measurements are made with the use of a gauge block kit. This method requires that the gap (to be taken up with the shim pack) be measured with

a. additional shims.
b. an inclinometer.
c. calipers.
d. a feeler gauge.
e. none of the above.

____ 17. One method of achieving the correct drive pinion depth is to compare the depth marking on the old gear with

a. the one inscribed on the pinion bearings.
b. the one inscribed on the differential housing.
c. the one inscribed on the side gears.
d. the one recorded in the manufacturer's manual.
e. none of the above.

____ 18. Normal manufacturing tolerance differences require that the adjustment of bearing preload on new drive pinion gears be made

a. at the time of manufacture.
b. at the same time as side gears are adjusted.
c. at the time of differential assembly.
d. after the new gears have been performance tested.
e. at none of the above times.

SECTION B. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 19. When installing the drive pinion, the technician should lubricate the drive pinion bearing races and seal with gear lube.

____ 20. Most manufacturers use a collapsible spacer between the drive pinion bearings.

____ 21. Pitch line denotes the alignment of gears with other gears and their shafts.

____ 22. The drive side of a ring gear tooth is somewhat concave (sloping inward) in shape.

____ 23. The coast side of the ring gear tooth is somewhat convex (bulging outward) in shape.

____ 24. Ring and drive pinion gears must always be installed as a matched set. The gear ratio will establish the size and number of teeth on the gears.

____ 25. Hunting ring and pinion gears have timing marks, which must be aligned as the gears are meshed during case installation.

____ 26. Cases with spanner adjusters should be only slightly tightened--usually to about 10 ft.lbs.

____ 27. When using a dial indicator to record backlash of a drive pinion gear, the technician should make sure the gear is rotating.

____ 28. When checking gear tooth contact pattern, the technician should apply suitable marking grease to the teeth of the ring gear.

____ 29. The technician should check axle side gear clearance by inserting two feeler gauges between the differential case and side gear shim washers.

____ 30. Axle side gear clearance can be adjusted by repositioning the axle side gears.

____ 31. If the rear U-joint operates at an excessive angle, nonconstant velocity vibrations may occur.

____ 32. One tool that can be used to check differential alignment is the feeler gauge.

____ 33. When aligning the drive shaft, the technician should take two inclinometer readings at the appropriate positions. The technician should then divide the first reading into the second to determine the correct rear U-joint angle.

____ 34. Rear U-joint adjustment may be made by repositioning control arms, using shorter or longer control arms, or using shims.

____ 35. Following differential installation and adjustment, the technician should conduct a performance test at very low speeds (no more than 10 mph).

(NOTE: The student must obtain a minimum score of ______ on Part II of the Unit IX Test in order to receive an evaluation for Competency Cc3.)

ANSWERS TO UNIT IX TEST

1. c
2. e
3. d
4. a
5. ad
6. b
7. ab
8. b
9. c
10. d
11. d
12. a
13. c
14. c
15. a
16. d
17. e
18. c
19. t
20. t
21. f
22. f
23. f
24. t
25. f
26. t
27. f
28. t
29. t
30. f
31. t
32. f
33. f
34. t
35. f

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the principles of transaxle operation and diagnose transaxle problems. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with transaxle operation (Competencies Aa1-Aa3 and Bb1, Part I of the Unit X Test).

II. Identify transaxle components and how they function (Competencies Aa1-Aa3, Part I of the Unit X Test).

III. Identify the manner in which the transaxle operates (Competencies Aa1-Aa3, Part I of the Unit X Test).

Lesson 2. I. Identify appropriate procedures for diagnosing the clutch assembly, transmission, and differential assembly in transaxle vehicles (Competency Aa1, Parts I and II of the Unit X Test).

II. Identify appropriate procedures for diagnosing a half shaft (Competency Bb1, Parts I and II of the Unit X Test).

III. Demonstrate the ability to:

- a. Diagnose, performance test, and determine needed repairs for a manual transaxle (Competencies Aa1 and Bb1, JS1-L2-UX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheet in this unit covers ASE tasks C001, C002, C011, C027, C046 and C047.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: MANUAL TRANSAXLE OPERATION

a. Information outline

2. Lesson 2: MANUAL TRANSAXLE DIAGNOSIS

a. Information outline

b. Assignment sheets

AS1-L2-UX: Procedure for Servicing and Adjusting a Shift Linkage

c. Job sheets

JS1-L2-UX: Diagnosing, Performance Testing, and Determining Needed Repairs for a Manual Transaxle

E. Unit test

F. Answers to unit test

REFERENCES

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Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should perform AS1-L2-UX in conjunction with JS1-L2-UX.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
   3. Automatic Transaxle Removal, Disassembly, and Inspection (AM-86-600), 1986.
   4. Servicing and Repair of Front-Wheel Drive Axles (AM-86-602), 1986.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS

LESSON 1: MANUAL TRANSAXLE OPERATION

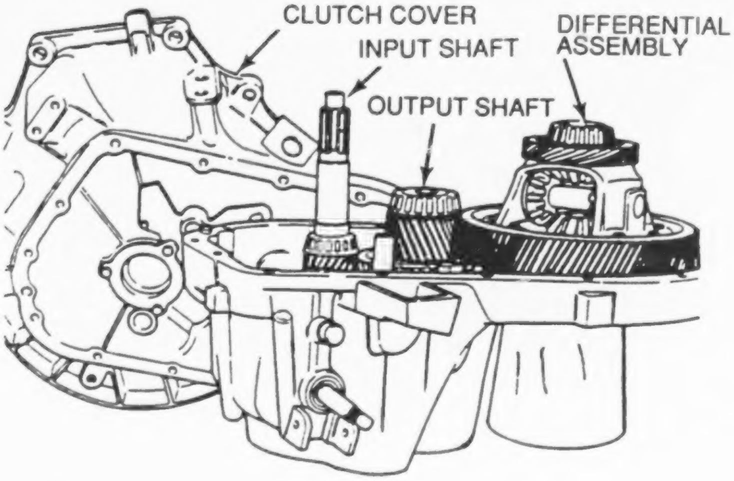
I. Terms and definitions

- A. Ball joint--A flexible ball and socket joint used to join the spindle to the control arm.
- B. Boot--A flexible rubber covering for the universal joint of a front-wheel-drive half shaft.
- C. Engine holding fixture--A cross brace that spans the engine compartment of a front-wheel-drive vehicle and holds the engine.
- D. MacPherson strut--A front-suspension design in which the wheel spindle attaches directly to a sturdy telescopic tube and spring assembly. This design eliminates the need for an upper control arm. The MacPherson strut also contains a shock absorber.
- E. Rzeppa joint--A type of universal joint consisting of an inner and outer race and hardened steel balls. The Rzeppa joint is flexible and operates at a constant velocity regardless of the angle of the shafts.
- F. Spindle (steering knuckle)--The iron or steel axle and brace that support the front wheel hub on its bearings. The spindle attaches to ball joints and/or a MacPherson strut.
- G. Tripod joint--A type of universal joint containing three steel balls, which rotate on a central cross or "spider," and engage the machined cavity of a housing. This flexible joint operates at a constant velocity regardless of the angle of the shafts.

II. Transaxle components and how they function

- A. Description of transaxle
    - 1. The transaxle unit contains the transmission. The transaxle may have either four or five forward speeds.
    - 2. The transaxle also contains the differential.

3. On vehicles with transaxles, the output of the differential portion of the transaxle connects to the front driving hubs and wheels through a pair of axles called half shafts.



4. The manual transaxle case covers the flywheel and clutch assembly.

B. The transaxle housing is cast of aluminum. The housing contains the transmission, differential, and clutch. The housing bolts to the rear of the engine and attaches to the frame of the vehicle with rubber mounts.

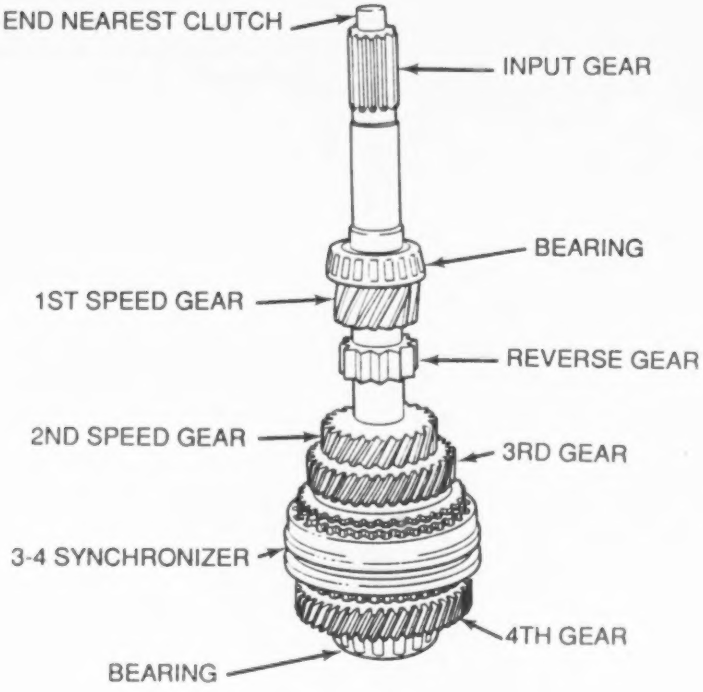
C. The input shaft of the manual transaxle runs completely through the case and contains more than one gear. This arrangement eliminates the need for a counter gear (cluster gear).

1. The input shaft is supported at the front of the case (bellhousing area) by an inward-facing, tapered roller bearing.

2. The input shaft is supported at the back of the case by an inward-facing tapered roller bearing. This bearing is larger than the front bearing.

3. The end of the front of a manual transaxle input shaft looks like the input shaft of a manual transmission. The end of the front of a manual transaxle input shaft is machined down on the end to fit the pilot bushing in the engine crankshaft; the end also has splines to engage the center hub of the clutch disc.

4. An input bearing retainer collar shrouds the input shaft and provides a sleeve for the throw-out bearing.



Courtesy of General Motors Corporation

(NOTE: Manual transaxles vary in component design and operation. To some degree, this variation depends upon the number of forward speeds offered by the transaxle and design decisions made by the manufacturer. The information below applies to most four-speed transaxles. Refer to a manual for specific design variations and procedures.)

5. The first speed drive gear is the first gear found on the input shaft. The first speed drive gear is machined into the shaft and turns the first gear on the output shaft (mainshaft).

6. The reverse drive gear is the second gear found on the input shaft. The reverse drive gear turns the reverse idler gear. The reverse drive gear is also machined into the input shaft.

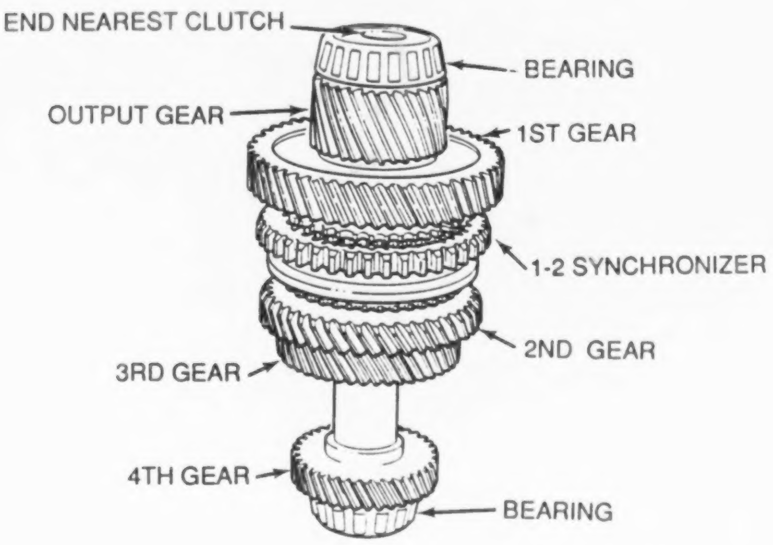
7. The second speed drive gear is machined into the input shaft and turns second gear on the output shaft (mainshaft).

8. The third speed drive gear spins freely on the input shaft and engages the third gear of the output shaft.

9. The hub of this 3-4 synchronizer assembly is splined to the input shaft.

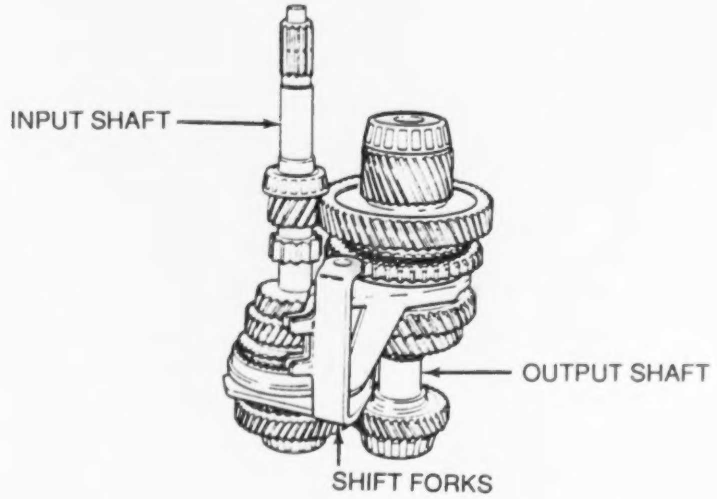
10. The fourth speed gear spins freely on the input shaft and engages fourth gear of the output shaft.

D. Output shaft (mainshaft)


END NEAREST CLUTCH
BEARING
OUTPUT GEAR
1ST GEAR
1-2 SYNCHRONIZER
2ND GEAR
3RD GEAR
4TH GEAR
BEARING

Courtesy of General Motors Corporation

1. The output shaft is supported in the case at both ends by inward-facing, tapered roller bearings.
2. The output gear is the differential pinion gear. The differential pinion gear is the first gear machined into the output shaft. The differential pinion gear meshes with and turns the differential ring gear.
3. The first speed gear spins freely on the output shaft.
4. The center hub of the first-second synchronizer assembly splines to the output shaft.
5. The second speed gear spins freely on the output shaft.
6. The third speed gear is splined to the output shaft.
7. The fourth speed gear is splined to the output shaft.



Courtesy of General Motors Corporation

E. The reverse idler gear can slide on a shaft to engage the reverse drive gear on the input shaft and the external teeth on the first-second synchronizer assembly.

F. Differential assembly

1. The ring gear in the differential assembly meshes with the output gear on the output shaft.

2. The differential case is cast of aluminum. The case has the ring gear bolted to it. The case turns on a bearing at each end.

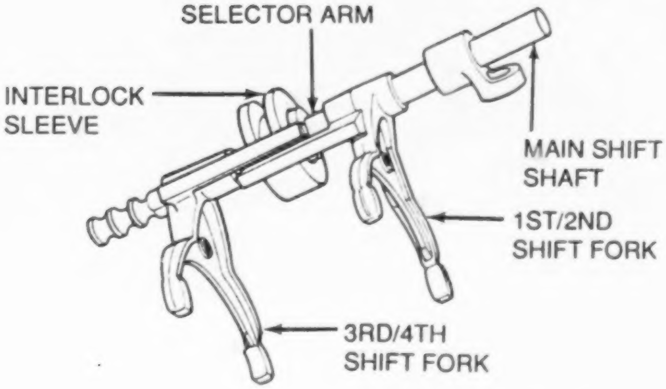
3. The differential pinion shaft sits diagonally in the differential case. The shaft is retained by a bolt.

4. The differential pinion gears are spur bevel gears. The differential pinion gears are free to spin on the pinion shaft inside the differential case. Shim washers reduce friction against the case.

5. The axle side gears are spur bevel gears. They mesh with the differential pinion gears and have internal splines to engage the axles. Shim washers reduce friction against the case.

6. The speedometer drive gear is pressed onto the differential case.

G. Shift rails are moved by shift levers on the outside of the transaxle case. The shift forks are on these rails. The forks straddle grooves in the synchronizer sleeves. A detent system retains the forks and rails in position.


SELECTOR ARM
INTERLOCK SLEEVE
MAIN SHIFT SHAFT
1ST/2ND SHIFT FORK
3RD/4TH SHIFT FORK

Courtesy of Ford Motor Company

H. Half shafts

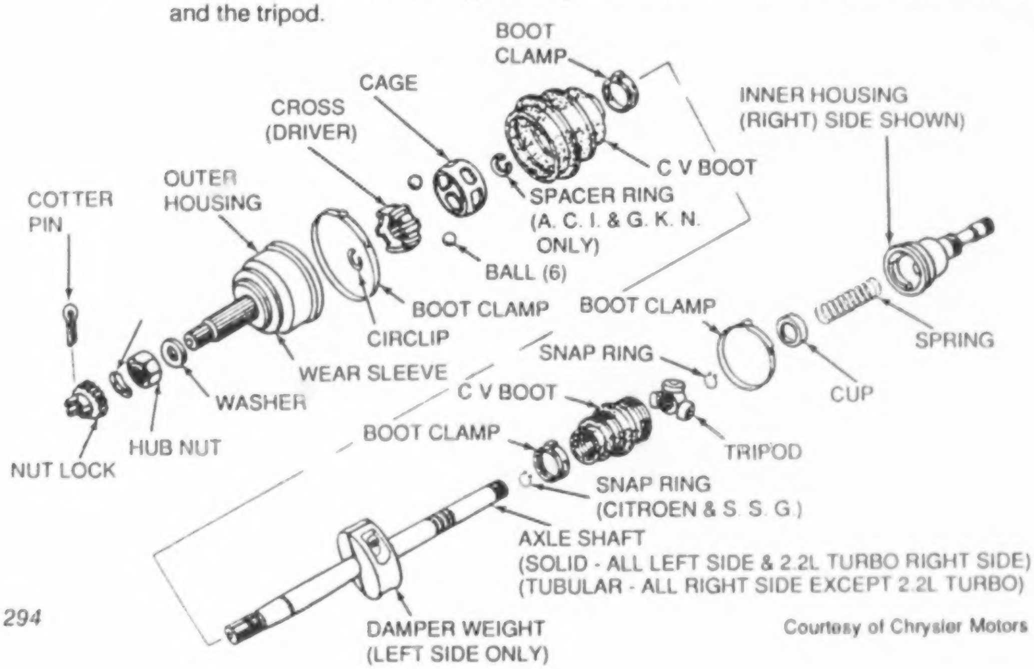
1. The half shafts are the driving axles of a front-wheel-drive vehicle.

2. The half shafts usually differ in length due to the offset of the differential portion of the transaxle assembly.

3. Each of the half shafts has two universal joints to allow for movement of the front suspension and steering.

4. Half shafts must use constant velocity U-joints to allow for flexibility and to prevent vibration.

5. The two most common types of joints used in the half shaft are the Rzeppa and the tripod.


BOOT CLAMP
CAGE
CROSS (DRIVER)
INNER HOUSING (RIGHT) SIDE SHOWN)
C V BOOT
OUTER HOUSING
COTTER PIN
SPACER RING (A. C. I. & G. K. N. ONLY)
BALL (6)
BOOT CLAMP
BOOT CLAMP
CIRCLIP
SPRING
SNAP RING
WEAR SLEEVE
CUP
WASHER
C V BOOT
BOOT CLAMP
TRIPOD
HUB NUT
NUT LOCK
SNAP RING (CITROEN & S. S. G.)
AXLE SHAFT (SOLID - ALL LEFT SIDE & 2.2L TURBO RIGHT SIDE) (TUBULAR - ALL RIGHT SIDE EXCEPT 2.2L TURBO)
DAMPER WEIGHT (LEFT SIDE ONLY)

Courtesy of Chrysler Motors

6. The joints are lubricated with special grease and protected by rubber boots.

7. The ends of the half shafts are splined to engage the side gears inside the transaxle and the front-wheel hubs.

III. Transaxle operation

(NOTE: Manual transaxles vary in component design and operation. This variation depends to some degree upon the number of forward speeds and design decisions made by the manufacturer. The following information applies to most four-speed transaxles. Refer to a manual for specific design variations and procedures.)

A. Clutch operation in a manual transaxle vehicle is almost identical to that found in conventional rear-wheel-drive vehicles. The clutch linkage in manual transaxle vehicles does, however, have some modifications. These modifications are listed below.

1. The clutch fork and ball pivot are replaced with a clutch fork shaft. The clutch fork shaft turns on bushings in the transaxle case.

2. The clutch fork shaft is connected to an external lever that, in turn, connects to the clutch pedal linkage.

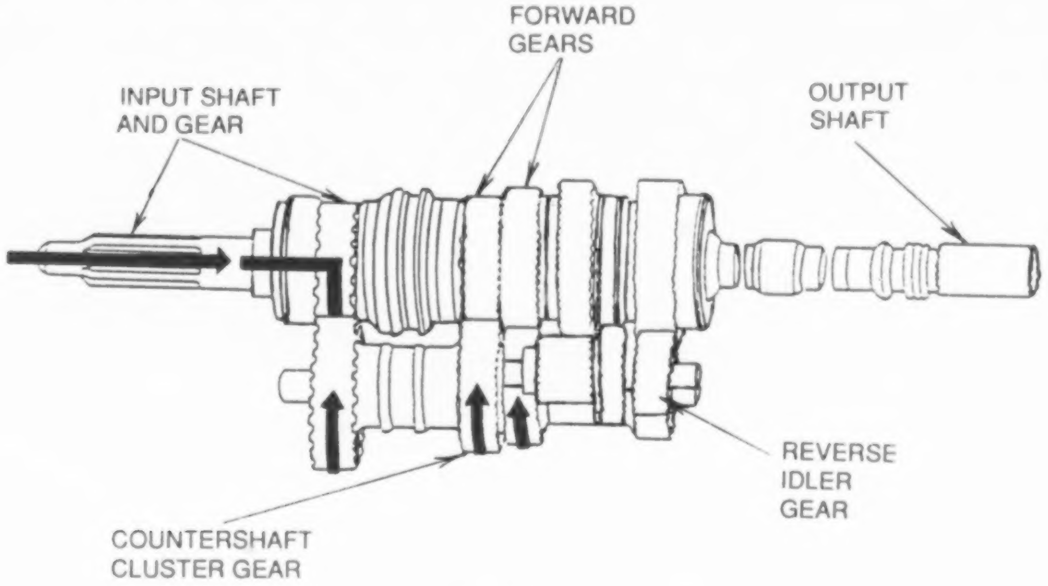
3. Most manual transaxles use either a cable or a hydraulic clutch linkage.

B. Neutral

1. Both synchronizer sleeves are in the middle (neutral) position.

2. The input shaft can turn if the clutch is engaged.

3. No gears are engaged; therefore, no power is transferred.

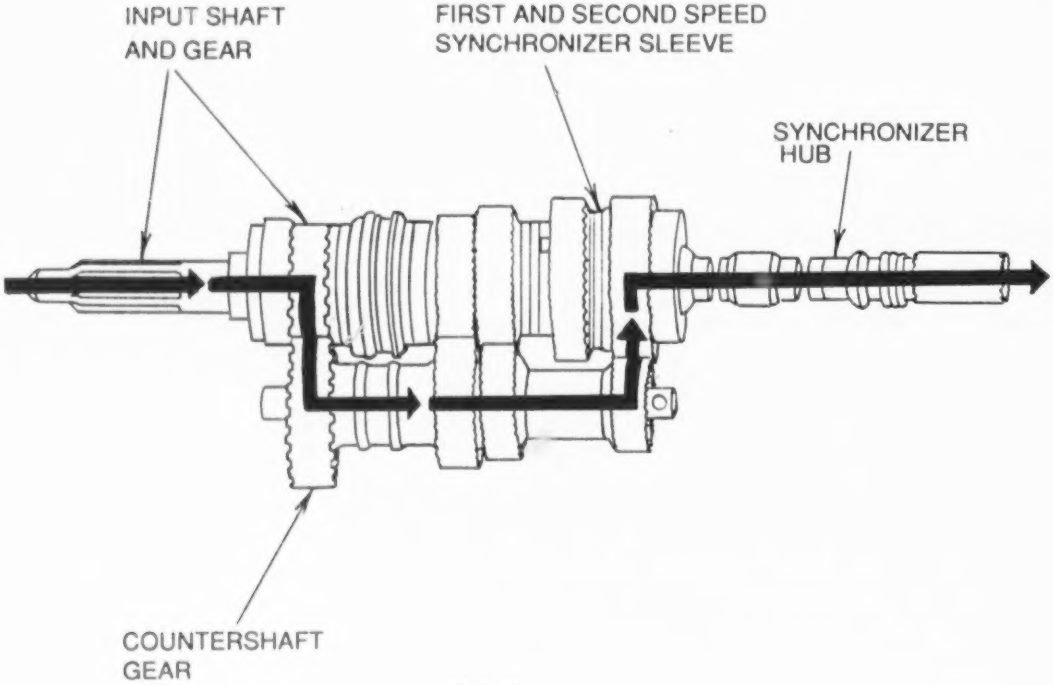


NEUTRAL

MDT 295

C. First gear

1. The first-second synchronizer sleeve (moved by the shift fork and rail assembly) slides over to engage the external synchronizer teeth of first gear on the output shaft.
2. The input shaft first drive gear turns the first driven gear on the output shaft.
3. The first driven gear is locked to the output shaft through the first-second synchronizer sleeve and hub.
4. The output shaft turns.
5. The output gear on the output shaft turns the differential ring gear and assembly.


INPUT SHAFT AND GEAR
FIRST AND SECOND SPEED SYNCHRONIZER SLEEVE
SYNCHRONIZER HUB
COUNTERSHAFT GEAR

FIRST

D. Second gear

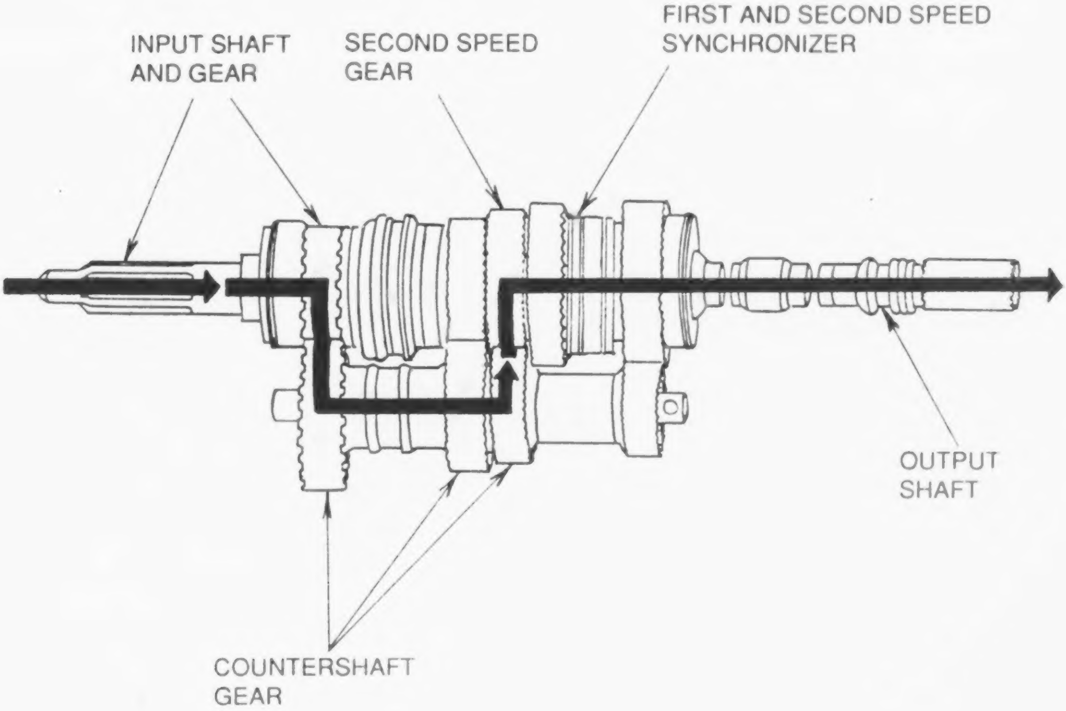
1. The first-second synchronizer sleeve is moved through the center neutral position until the sleeve engages the external synchronizer teeth on second gear.

2. The input shaft second speed drive gear turns the second speed driven gear on the output shaft.

3. The second driven gear is locked to the output shaft through the first-second synchronizer sleeve and hub.

4. The output shaft is turned at a slightly higher ratio than first gear.

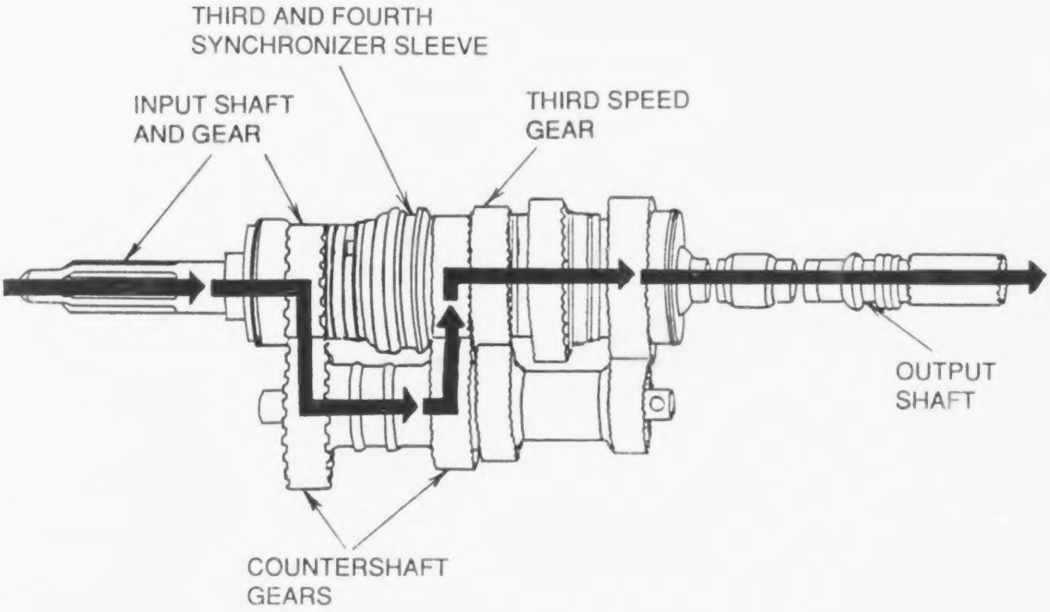
5. The output gear on the output shaft turns the differential ring gear and assembly.


INPUT SHAFT
AND GEAR
SECOND SPEED
GEAR
FIRST AND SECOND SPEED
SYNCHRONIZER
OUTPUT
SHAFT
COUNTERSHAFT
GEAR

SECOND

E. Third gear

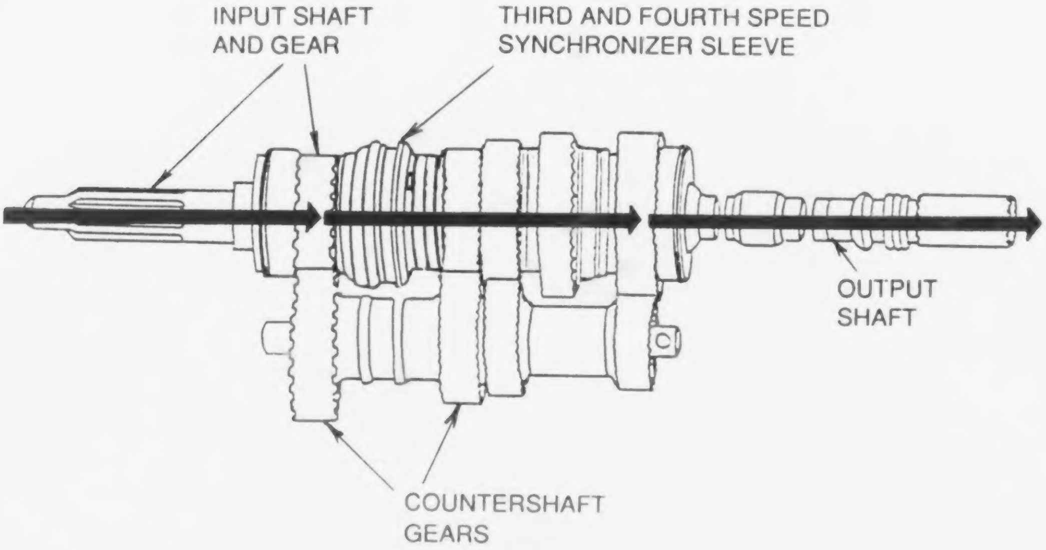
1. The first-second synchronizer sleeve is moved back to neutral (center) position.
2. The third-fourth synchronizer sleeve is moved over to engage the external synchronizer teeth of third gear on the input shaft assembly.
3. The input shaft engages and turns third gear by way of the hub and synchronizer sleeve.
4. The third drive gear on the input shaft turns the third driven gear on the output shaft at a slightly higher ratio than second gear.
5. The output shaft drives the differential ring gear and assembly.


THIRD AND FOURTH SYNCHRONIZER SLEEVE
INPUT SHAFT AND GEAR
THIRD SPEED GEAR
OUTPUT SHAFT
COUNTERSHAFT GEARS

THIRD

F. Fourth gear

1. The third-fourth synchronizer sleeve is moved through the neutral (center) position until the sleeve engages the external synchronizer teeth of the fourth gear on the input shaft.
2. The input shaft engages and turns forth gear by way of the hub and synchronizer sleeve.
3. The fourth drive gear on the input shaft turns the fourth driven gear on the output shaft at a 1-1 ratio (direct drive).
4. The output shaft gear drives the differential ring gear and assembly.


INPUT SHAFT AND GEAR
THIRD AND FOURTH SPEED SYNCHRONIZER SLEEVE
OUTPUT SHAFT
COUNTERSHAFT GEARS

FOURTH

G. Reverse gear

1. Both synchronizer sleeves are returned to the neutral (center) position.

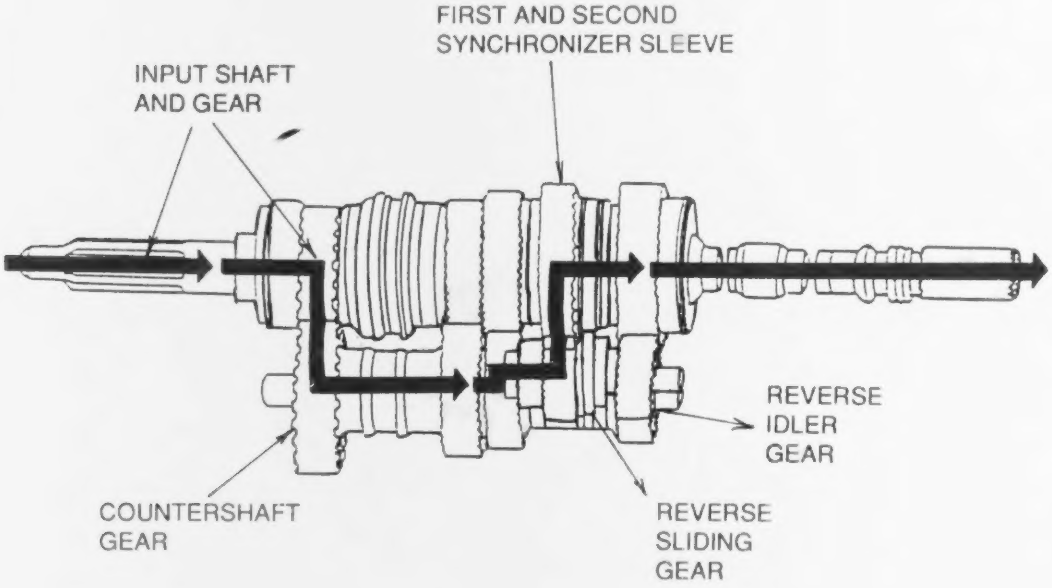
2. The sliding reverse idler gear, moved by a shift fork and shaft assembly, engages the reverse drive gear on the input shaft and external teeth on the first-second synchronizer sleeve.

3. The input shaft turns the reverse idler gear.

4. The reverse idler gear turns the first-second synchronizer sleeve in the opposite direction at a low gear ratio.

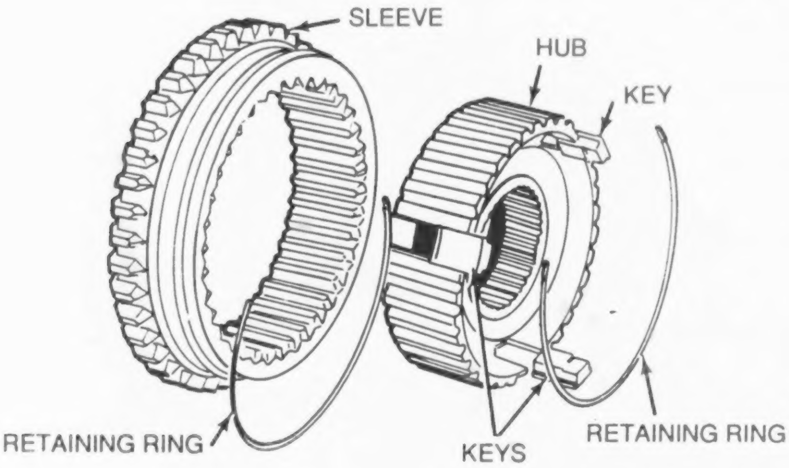
5. The first-second synchronizer sleeve turns the hub and output shaft.

6. The output shaft gear turns the differential ring gear and assembly. This assembly turns in a direction opposite to that of the forward gears.


FIRST AND SECOND SYNCHRONIZER SLEEVE
INPUT SHAFT AND GEAR
REVERSE IDLER GEAR
COUNTERSHAFT GEAR
REVERSE SLIDING GEAR

REVERSE

H. The synchronizer system in a manual transaxle operates in exactly the same way as the synchronizer system in a manual rear-wheel-drive transmission. Refer to Unit II, Manual Transmission Components and their Operation, for review.



Courtesy of General Motors Corporation

I. The differential in a manual transaxle assembly operates in exactly the same way as the differential in a rear-wheel-drive vehicle. Refer to Unit VIII, Differential Diagnosis and Removal, for review.

J. Lubrication is splashed on all internal components of the manual transaxle assembly during operation.

(NOTE: Some manufacturers find that the use of heavy gear lube in transaxle assemblies results in hard shifting during cold weather operation. Manufacturers recommend the use of automatic transmission fluid. Always refer to the manufacturer's recommendation for the proper type and quantity of lubricant to be used.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS

LESSON 2: MANUAL TRANSAXLE DIAGNOSIS

I. The operation and design of the clutch assembly, the transmission, and the differential are exactly the same as in a rear-wheel-drive vehicle. Therefore, the methods of diagnosing these components in a transaxle vehicle are generally the same as those used for a rear-wheel-drive vehicle. In some cases, different diagnostic procedures are needed for transaxles; these procedures are listed below.

(NOTE: Refer to Units III, V, and VIII for diagnostic procedures and trouble shooting charts relating to the clutch, the transmission, and the differential.)

A. If the transmission of a vehicle equipped with a transaxle shifts hard in cold weather, check for improper lubricant in the transaxle.

(NOTE: Because thick lubricants cause hard shifting in cold weather, they are generally not used in transaxles. Refer to manufacturer's recommendations for the proper type of lubricant to be used and the level to which the lubricant is to be filled.)

B. In vehicles with transaxles, a loud clank (called cradle clank) heard during acceleration can be caused by any of the problems listed below.

1. Loose or worn transaxle mounts
2. Weak or loose mounts on the subframe assembly
3. A worn engine torque shock absorber (at the top of the engine)

(NOTE: Loose or worn bushings surrounding an engine torque shock absorber may also cause cradle clank.)

C. Inspection and repair of the internal workings of the clutch on vehicles with transaxles requires that the entire transaxle be lowered from the vehicle. Refer to Unit XI for procedures for lowering the transaxle.

D. In vehicles with transaxles, the technician should check for lubricant leaks at the case and seals.

II. Half shaft diagnosis

A. It is extremely important that the rubber boots that cover the half shaft joints be in good condition (free of cracks and tears). They should also be clamped in the proper position. Any leakage around the boots will result in the loss of lubrication. (The openings that allow leakage will also allow water and dirt to enter the boot.) A torn boot can cause premature failure of the joint.

B. A worn CV joint in a half shaft will result in vibration or shudder, particularly when the vehicle is under power and in a turn. The technician can inspect the half shaft by grasping it near the joint and checking for looseness. It may also be necessary to remove the shaft for inspection. Refer to Unit XI for procedures.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR SERVICING AND ADJUSTING A SHIFT LINKAGE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for servicing and adjusting the shift linkage.

JS1-L2-UX

MODULE: MANUAL DRIVE TRAIN AND AXLES

DIAGNOSING, PERFORMANCE TESTING, AND DETERMINING NEEDED REPAIRS FOR A MANUAL TRANSAXLE

Equipment:

Hand tools
Hoist
Service light
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine if the manual transmission's linkage is properly adjusted. __ __ __ __

    a. Check the clutch pedal free travel. Free travel should not exceed more than 1 inch.

    OK _____ NOT OK _____

    b. Does the clutch system have any of the following problems?

    Worn linkage
    Bent linkage
    Defective clutch cable
    Defective hydraulic system
    Loose transmission bolts
    Loose ball housing bolts
    Binding or sticking clutch peddle

    Yes _____ No _____

    c. If the answer to any of the questions in item "b" was yes, please explain the problem and list steps to correct the problem(s).

3. Following the procedure outlined below, performance test the clutch on a vehicle equipped with a manual transaxle. — — — —

   a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, grabbing, slipping, or other unusual noise or activity.

   b. According to this test, is the clutch operating properly?

      Yes _____ No _____

   c. If no, recommend steps that should be taken to correct the situation.

4. Following the procedure outlined below, determine if the manual transaxle linkage is properly adjusted. — — — —

   a. Move the shift lever through all positions and note smoothness of operation. Improper shift rod adjustment will distort the H-pattern of the shift lever.

   b. Start vehicle (with the instructor's approval) and move the shift lever through all positions. Release clutch pedal slightly to verify forward, neutral, and reverse gear engagement.

   c. According to this test, is the shift linkage properly adjusted?

      Yes _____ No _____

      If yes, proceed to item 5.
      If no, proceed to items d through f.

   d. Complete AS1-L2-UX.

   e. Following the procedure developed in AS1-L2-UX, service and adjust the shift linkage.

   f. Repeat steps a through c.

5. Following the procedure outlined below, performance test a vehicle equipped with a manual transaxle. — — — —

   a. Start vehicle (with the instructor's approval) and drive slowly in low gear. Note any grinding, jumping out of gear, or other unusual noise or activity.

   b. Drive vehicle slowly in reverse and note any grinding, jumping out of gear, or other unusual noise or activity.

   c. Drive vehicle normally and shift through all gears. Note any grinding, gear engagement clash , or other unusual noise or activity.

   d. Transaxle noises may be localized with the use of a stethoscope. The vehicle must be running before a noise can be localized; therefore, carefully follow the instructor's safety recommendations when using a stethoscope to localize noises.

   e. Record the results of the performance test.

   f. If a problem was determined to be in the manual transaxle, recommend steps to correct the problem.

6. Following the procedure outlined below, test the CV joints for wear or torn boots. — — — —

   a. Place the vehicle securely on safety stands or lift with hoist.

   b. Visually inspect all four of the rubber boots that cover the CV joints. Record observations.

c. Grasp each of the CV joints on the shaft (as near the joint as possible) and try to wiggle the shaft. Record observations.

(NOTE: A very small amount of shaft movement is acceptable. Refer to the manufacturer's service manual for specifications.)

d. Start the vehicle (with the instructor's approval) and slowly drive it in a big lot. First turn the steering wheel hard (all the way) in one direction and drive in a circle. Note any grinding, clanking, popping, or other unusual activity. Record observations.

e. Reverse the direction of travel and drive in a circle. Note any grinding, clanking, popping or other unusual activity. Record observations.

f. If the problem was determined to be in the half shaft or CV joint, recommend steps to correct the problem.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competencies Aa1 and Bb1. Final evaluation for Aa1 and Bb1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Aa1 by averaging the final evaluation of JS1-L1-UIII and JS1-L2-UX. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UIII				
JS1-L2-UX				
Final evaluation for Competency Aa1				

II. Determine the student's final evaluation for Competency Bb1 by averaging the final evaluation of JS1-L3-UVI and JS1-L2-UX. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L3-UVI				
JS1-L2-UX				
Final evaluation for Competency Bb1				

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT X: MANUAL TRANSAXLE OPERATION AND DIAGNOSIS

UNIT X TEST

PART I: MANUAL TRANSAXLE OPERATION

SECTION A: Match the terms below with their correct definitions.

____ 1. A type of universal joint consisting of an inner and outer race and hardened steel balls.

____ 2. The iron or steel axle and brace that supports the front wheel hub on its bearings.

____ 3. A type of universal joint containing three steel balls that rotate on a central cross or "spider" and engage the machined cavity of a housing.

____ 4. A flexible rubber covering for the universal joint of a front-wheel drive half shaft.

____ 5. A front-suspension design that eliminates the need for an upper control arm by attaching the wheel spindle directly to a sturdy telescopic tube and spring assembly.

a. Ball joint

b. Boot

c. Engine holding fixture

d. MacPherson strut

e. Rzeppa joint

ab. Spindle (steering knuckle)

ac. Tripot joint

SECTION B: **Select the best answer from the five choices listed.**

____ 6. The transaxle unit contains

a. the transmission.
b. the differential.
c. clutch components.
d. all of the above.
e. none of the above.

____ 7. On vehicles with transaxles, the output of the differential portion of the transaxle connects to the front driving hubs and wheels through a pair of axles called

a. half shafts.
b. mainshafts.
c. trans-shafts.
d. output shafts.
e. none of the above.

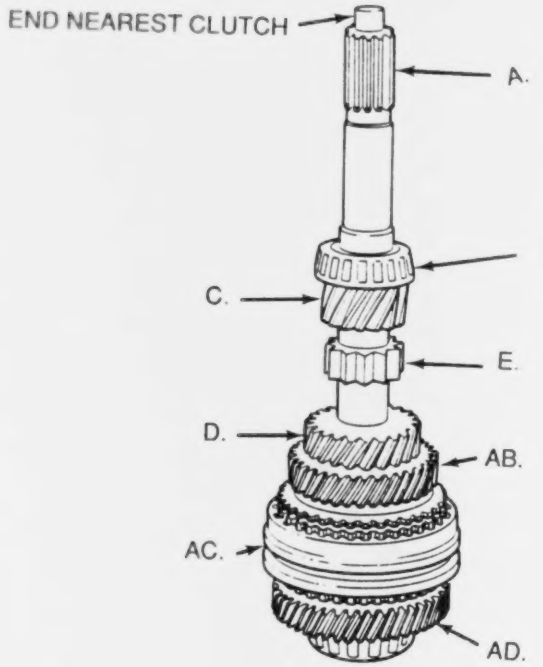
____ 8. The transaxle housing is cast of

a. iron.
b. steel.
c. lead.
d. aluminum.
e. none of the above.

____ 9. Unlike the traditional manual transmission, the input shaft of the manual transaxle runs completely through the case and contains more than one gear. This arrangement eliminates the need for

a. axle side gears.
b. drive pinion gears.
c. output gears.
d. a synchronizer gear.
e. a counter gear (cluster gear).

SECTION C: Shown below are various components of the input shaft. Place the letter of each component in the blank beside the component's name.



Courtesy of General Motors Corporation

____ 10. 4th gear

____ 11. input gear

____ 12. 3-4 synchronizer

____ 13. bearing

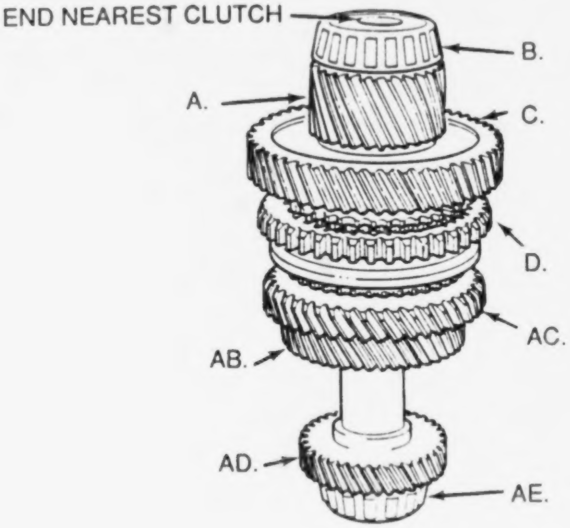
____ 14. reverse gear

____ 15. 3rd gear

____ 16. 1st speed gear

____ 17. 2nd speed gear

SECTION D. Shown below are various components of the output shaft. Place the letter of each component in the blank beside the component's name.


END NEAREST CLUTCH
B.
A.
C.
D.
AC.
AB.
AD.
AE.

Courtesy of General Motors Corporation

____ 18. 1-2 synchronizer

____ 19. 1st gear

____ 20. Bearing

____ 21. 4th gear

____ 22. 3rd gear

____ 23. output gear

____ 24. 2nd gear

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SECTION E. **Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.**

____ 25. The output shaft is supported in the case at both ends by inward-facing tapered roller bearings.

____ 26. The first speed gear is splined to the output shaft.

____ 27. The second speed gear is splined to the output shaft.

____ 28. The third speed gear usually does not need a synchronizer.

____ 29. The third speed gear is splined to the output shaft.

____ 30. The center hub of the first-second synchronizer assembly spins freely on the output shaft.

____ 31. The reverse idler gear can slide on a shaft to engage the reverse drive gear on the input shaft and the external teeth on the first-second synchronizer assembly.

____ 32. The differential case is cast of aluminum.

____ 33. The differential pinion shaft runs diagonally through the differential case. The shaft is retained by a bolt.

____ 34. Shift rails are moved by shift levers on the inside of the transaxle case.

____ 35. The half shafts are the driving axles of the front-wheel-drive vehicle.

____ 36. Half shafts are usually the same length as the drive shafts found in two-wheel-drive vehicles.

____ 37. Each half shaft has three universal joints.

____ 38. The two most common types of joints used in the half shaft are the Rzeppa and ball joint.

____ 39. In vehicles with a transaxle, the clutch fork and ball pivot are replaced with a clutch fork shaft.

____ 40. Most manual transaxles use a cable clutch linkage.

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit X Test in order to receive a final evaluation for Competencies Aa1-Aa3 and Bb1.)

PART II. DIAGNOSING THE MANUAL TRANSAXLE

SECTION A. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 41. Technician I says that improper lubricant in transaxle can result in hard shifting during cold weather.

Technician II says that loose or worn mounts on the subframe assembly can cause a vehicle with transaxle to make a loud clanking sound (called cradle clank) during acceleration.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 42. Technician I says that thick lubricants should be used in in the transaxle.

Technician II says that repair of the internal workings of the clutch on vehicles with transaxles can be done without removing the transaxle from the vehicle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 43. Technician I says that the technician should check for lubricant leaks at the case and seals in vehicles with transaxles.

Technician II says that loose or worn transaxle mounts can cause a vehicle to make a loud clanking sound (called cradle clank) during acceleration.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 44. Technician I says that some leakage from rubber boots that cover the half shaft joints is to be expected.

Technician II says that the half shaft can be inspected by grasping it near the joint and checking for looseness.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 45. Technician I says that a worn joint in a half shaft will produce no symptoms until it finally breaks and disables the vehicle.

Technician II says that the methods for diagnosing transaxle components are generally the same as those used for rear-wheel drive components.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on Part II of the Unit IV Test in order to receive a final evaluation for Competencies Aa1 and Bb1.)

ANSWERS TO UNIT X TEST

1. e
2. ab
3. ac
4. b
5. d
6. d
7. a
8. d
9. e
10. ae
11. a
12. ac
13. b
14. e
15. ab
16. c
17. d
18. d
19. c
20. b
21. ad
22. ab
23. a
24. ac
25. t
26. f
27. f
28. t
29. t
30. f
31. t
32. f
33. t
34. f
35. t
36. f
37. f
38. f
39. t
40. t
41. c
42. d
43. a
44. c
45. b

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

UNIT OBJECTIVE

After completing this unit, the student will be able to remove, repair, install, and adjust a manual transaxle. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify safety precautions that should be taken during manual transaxle removal (Competency Aa2, Part I of the Unit XI Test).

II. Identify the proper procedures for removing the manual transaxle (Competency Aa2, Part I of the Unit XI Test).

III. Identify the proper procedure for disassembling the manual transaxle (Competency Aa2, Part I of the Unit XI Test).

IV. Demonstrate the ability to:

a. Remove a manual transaxle from a vehicle (Competency Aa2, JS1-L1-UXI).

Lesson 2. I. Identify the procedures for cleaning and inspecting manual transaxle components (Competency Aa2, Part I of the Unit XI Test).

II. Identify the procedures for removing, installing, and adjusting clutch assemblies in vehicles with manual transaxles (Competency Z2, Part I of the Unit XI Test).

III. Identify the procedures for reassembling and adjusting the manual transaxle (Competency Aa3, Part II of the Unit XI Test).

IV. Identify the procedures for half shaft repair (Competency Bb2, Part II of the Unit XI Test).

V. Demonstrate the ability to:

a. Disassemble, clean, and inspect manual transaxle components (Competency Aa2, JS1-L2-UXI).

b. Service the clutch on a vehicle with a manual transaxle (Competency Z2, JS2-L2-UXI).

c. Reassemble a manual transaxle (Competency Aa3, JS3-L2-UXI).

d. Service a half shaft and CV joint (Competency Bb2, JS4-L2-UXI).

Lesson 3. I. Identify the procedures for installing a manual transaxle (Competency Aa3, Part II of the Unit XI Test).

II. Identify the procedures for performance testing a transaxle after service is complete (Competency Aa3, Part II of the Unit XI Test).

III. Demonstrate the ability to:

a. Reinstall and adjust a manual transaxle (Competency Aa3, JS1-L3-UXI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks C004-C007, C016, C018-C026, C028-C040, C042-C045, C046, C047, C049 and C050. The job sheets can be adapted to cover C008-C010.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: TRANSAXLE REMOVAL AND DISASSEMBLY

    a. Information outline

    b. Assignment sheets

      AS1-L1-UX1: Procedure for Removal of a Manual Transaxle

    c. Job sheets

      JS1-L1-UXI: Removing a Manual Transaxle

  2. Lesson 2: TRANSAXLE CLEANING, INSPECTION, AND ASSEMBLY

    a. Information outline

    b. Assignment sheets

      AS1-L2-UXI: Procedures for Inspection and Disassembly of Manual Transaxle Components

      AS2-L2-UX1: Procedures for Manual Transaxle Reassembly

      AS3-L2-UXI: Procedures for Half Shaft and CV Joint Service

    c. Job sheets

      JS1-L2-UXI: Disassembling, Cleaning, and Inspecting Manual Transaxle Components

      JS2-L2-UXI: Servicing the Clutch on a Vehicle with a Manual Transaxle

      JS3-L2-UXI: Reassembling a Manual Transaxle

      JS4-L2-UXI: Servicing a Half Shaft and CV Joint

3. Lesson 3: TRANSAXLE INSTALLATION AND PERFORMANCE TESTING
    a. Information outline
    b. Assignment sheets
        AS1-L3-UXI: Reinstalling a Manual Transaxle
    c. Job sheets
        JS1-L3-UXI: Reinstalling and Adjusting a Manual Transaxle

E. Unit test

F. Answers to unit test

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Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The final average of JS2-L2-UXI may also serve as a full evaluation for Competency Z2 if the student does not complete JS1-L2-UV.

2. Students should perform AS1-L1-UXI in conjunction with JS1-L1-UXI, AS1-L2-UXI in conjunction with JS1-L2-UXI, AS2-L2-UXI in conjunction with JS3-L2-UXI, and AS3-L2-UXI in conjunction with JS4-L2-UXI.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
3. Axle Bearing and Seal Replacement (AM-84-452), 1984.
4. Automatic Transaxle Removal, Disassembly, and Inspection (AM-86-600), 1986.
5. Servicing and Repair of Front-Wheel Drive Axles (AM-86-602), 1986.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

LESSON 1: TRANSAXLE REMOVAL AND DISASSEMBLY

I. Safety in transaxle removal

A. Before removing the transaxle, the technician must raise the vehicle and support it on jackstands. When raising a front-wheel-drive vehicle, adherence to correct procedures is very important. Raising a front-wheel-drive vehicle improperly can bend the rear suspension and cause other serious damage to the underside of the vehicle. Refer to the manufacturer's recommendations for raising and supporting the vehicle. Raise and support the vehicle only with the supervision of the instructor.

B. The transaxle provides part of the support for the engine. When the transaxle is removed, the engine must, therefore, be supported properly with the appropriate engine holding fixture.

C. When working on transaxles, the technician must wear proper clothes, shoes, and approved safety glasses.

II. Procedures for removing the transaxle

(NOTE: Procedures for removing manual transaxles vary, depending on vehicle model. The technician should refer to a service manual to obtain the proper procedures for the particular vehicle to be serviced.)

A. Disconnect the negative battery cable. Doing so eliminates the hazard of sparks and fire during removal of the transaxle.

B. Disconnect all cables and linkages attached to the transaxle. Listed below are various cables and linkages that may have to be removed.

1. Shift linkage

2. Clutch linkage (cable)

3. Speedometer cable

4. Wires

5. Fuel lines

C. Either place the vehicle securely on safety stands or lift vehicle with a hoist.

D. Drain lubricant from transaxle.

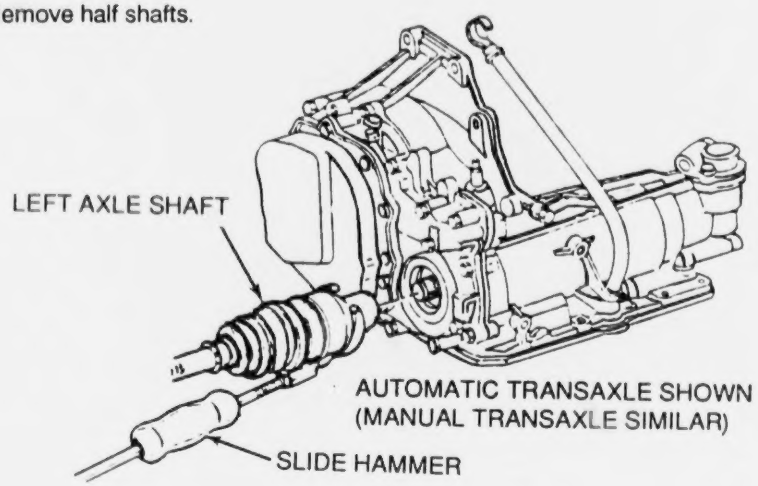
E. Remove front wheels.

F. Disconnect half shafts from front hubs. It may be necessary to separate the lower ball joint or unbolt the spindle.

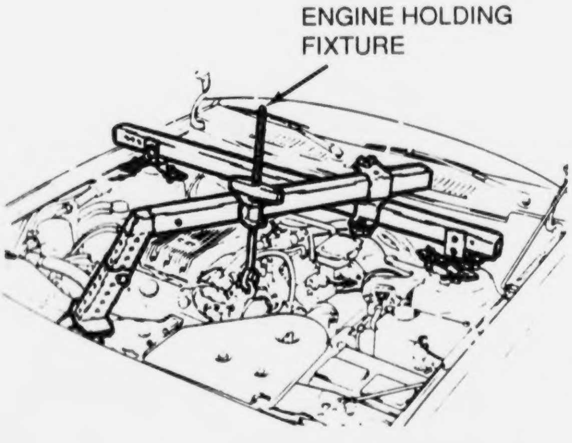
(**NOTE**: When used in reference to front-wheel-drive vehicles, the terms "half shaft" and "axle shaft" may be used interchangeably.)

(**CAUTION:** On some transaxles, a support shaft must be installed after the removal of one axle shaft and before the removal of the other axle shaft. The support shaft will prevent the differential from falling out of its position within the transfer case.)

G. Remove half shafts.


LEFT AXLE SHAFT
AUTOMATIC TRANSAXLE SHOWN
(MANUAL TRANSAXLE SIMILAR)
SLIDE HAMMER

H. Install engine holding fixture and adjust it so that a slight amount of weight is taken off the engine mounts.


ENGINE HOLDING
FIXTURE

Courtesy of General Motors Corporation

I. Remove transaxle mounts and/or center support.

J. Remove any exhaust or air management system parts that may hamper transaxle removal.

K. Remove starter motor if required.

L. Remove engine mounts, if required, and lower engine and transaxle assembly slightly.

M. Support transaxle with an appropriate jack.

N. Remove bolts connecting transaxle bellhousing to engine.

O. Slide transaxle away from the engine; then lower the transaxle.

III. Transaxle disassembly

(NOTE: Exact procedures for transaxle disassembly vary depending on vehicle model. The technician should refer to a manual for correct procedures for the vehicle on which he or she is working.)

A. Place transaxle in holding stand, if available.

B. Some models require that the transaxle be in a specific shift position and that the shift rail detent system and reverse idler shafts be removed first. Refer to manual for procedures.

C. Remove bolts between case halves and separate the case.

D. Remove input shaft, output shaft, and differential assemblies from case.

E. Using appropriate pullers, remove bearings from input shaft assembly.

F. To remove remaining gears and synchronizer assemblies from input shaft, remove snap rings as required.

G. Using appropriate pullers, remove bearings from output shaft assembly.

H. To remove remaining gears and synchronizer assemblies from input shaft, remove snap rings as required.

I. Remove the bolt that holds the ring gear to the differential case. Remove the ring gear.

J. Using appropriate puller, remove bearings and speedometer drive gear from differential case.

K. Remove differential pinion shaft retaining bolt and then remove shaft.

L. Remove differential pinion gears and shim washers.

M. Remove axle side gears and shim washers.

N. Remove any shims from case halves. Mark shims to ensure that they are replaced in the proper location.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURES FOR REMOVAL OF A MANUAL TRANSAXLE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the manual transaxle.

JS1-L1-UXI

MODULE: MANUAL DRIVE TRAIN AND AXLES

REMOVING A MANUAL TRANSAXLE

Equipment:

Hand tools
Hoist
Serviceable vehicle
Transmission jack
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Complete AS1-L1-UXI. — — — —

2. Wear safety glasses while doing all procedures on this job sheet. — — — —

3. Place the vehicle securely on safety stands or lift with a hoist. — — — —

   (**CAUTION:** Remove the negative battery cable before raising the vehicle.)

4. Following the procedures developed in AS1-L1-UXI, remove the manual transaxle. Have the instructor approve the procedure before starting. — — — —

   (**CAUTION:** Make sure engine is properly supported before removing any of the transaxle supports.)

   (**CAUTION:** Never allow the vehicle weight to be placed on the front wheels if the spindle is not in the hub and the spindle not torqued to specification.)

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa2. Final evaluation will be made at the end of JS1-L2-UXI.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

LESSON 2: TRANSAXLE CLEANING, INSPECTION, AND ASSEMBLY

I. Procedures for cleaning and inspecting transaxle components

(**CAUTION**: Do not clean transaxle seals in solvent used for cleaning parts. Doing so may soften the rubber in some seals.)

A. Clean case halves and inspect for cracks, worn or damaged bearing bores, or damaged threads. Repair or replace parts as required. Clean shafts and gears in solvent.

B. Inspect mating surfaces. Remove small burrs carefully with file or fine stone.

C. Inspect reverse idler gear and shaft for damage or wear.

(NOTE: Because the idler gear is not synchronized, some clash damage can be expected. Minor damage to the gear is acceptable.)

D. Inspect the teeth, journals, and splines of the input shaft for damage or wear.

E. Inspect teeth, journals, and splines of the output shaft for damage or wear.

F. Inspect forward speed gears and synchronizer hubs and sleeves for wear or damage.

G. Inspect detent keys, springs, and brass synchronizer rings for breakage.

H. Inspect differential ring gear, pinion gears, and side gears for wear or damage. Inspect speedometer drive gear.

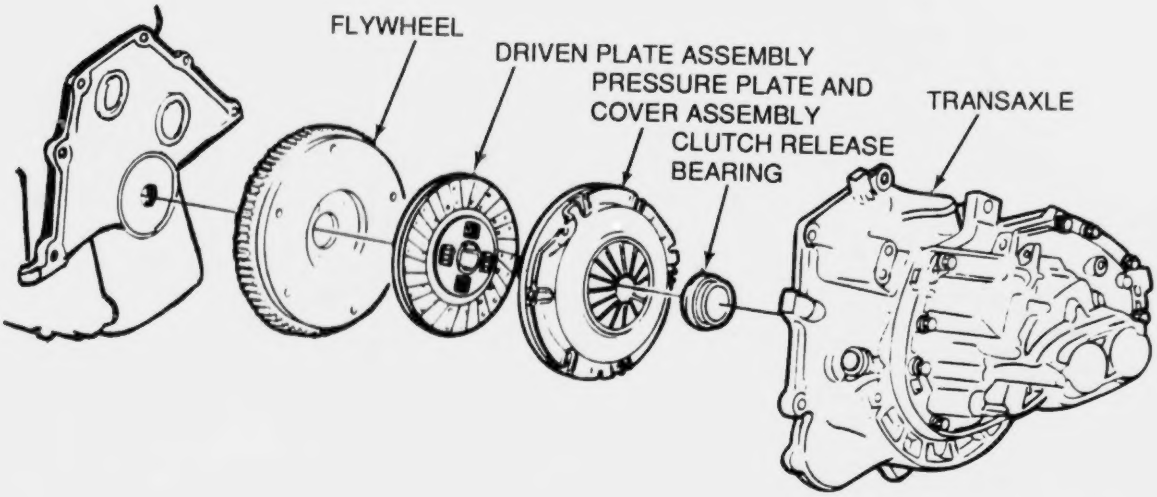
I. Inspect roller bearings for roughness by applying a light oil and turning with fingers. Check rollers for corrosion, wear, or burning.

(NOTE: Do not mix bearings. Bearings must be returned to their original locations along with any accompanying shims.)

J. Inspect shift forks and rails for wear and damage.

K. Inspect all detent balls and springs for wear or breakage.

II. The clutch assembly may be inspected and repaired after the transaxle has been removed. Procedures for removal, installation, and adjustment of the clutch assembly on a transaxle vehicle are essentially the same as for rear-wheel-drive vehicles. Refer to Unit V for procedures.



Courtesy of General Motors Corporation

III. Procedures for reassembling and adjusting the transaxle

(NOTE: Procedures for transaxle reassembly vary, depending on vehicle model. The technician should refer to a manual to obtain procedures appropriate for the vehicle on which he or she is working.)

A. During the process of reassembling a transaxle, a number of adjustments are required. The necessary adjustments that compensate for manufacturing tolerance differences are listed below.

   1. The preload against the input shaft bearings, output shaft bearings, and differential bearings is usually adjusted by adding shims. Turning torques are measured with inch lb. torque wrenches and special preload measuring tools.

   2. The end play clearance between gears and hubs requires adjustment. The clearance is usually measured with a feeler gauge.

B. Procedure for reassembling a transaxle

   1. If damage to a bearing was previously found, the bearing race (cup) must be replaced in the case. Use the appropriate removal and installation tools.

   2. If the clutch fork shaft was found to be loose, replace with new bushings. Apply a small amount of grease to bushings during installation.

3. Assemble the differential components in the order opposite from their disassembly. Apply lubrication to the components and torque ring gear bolts to specification. Use an appropriate tool to press bearings on case.

4. Lubricate and assemble the output shaft. Be sure that the slots in the synchronizer rings engage with the detent keys on the hub. Align marks on synchronizer sleeve with those on hub, if required. Make end play adjustments as required. Use an appropriate tool to press bearings on shaft ends.

5. Lubricate and assemble the input shaft. Be sure that the slots in the synchronizer rings engage with the detent keys on the hub. Align the marks on the synchronizer sleeve with those on the hub, if required. Make end play adjustments as required. Use an appropriate tool to press bearings on shaft ends.

6. Assemble shift fork and rail assemblies.

7. Install input shaft, output shaft, and differential assemblies into case. Measure and record turning torques. Make adjustments with replacement shims as required.

8. Install new seals in case halves with appropriate driving tools.

9. Install shaft and differential assemblies in case halves with shift forks and rails. Use new gaskets or recommended sealers as specified by the manufacturer. Tighten bolts to correct torque specification. Install front bearing retainer with gasket or sealer and then torque the bolts.

10. Complete assembly of shift rails, levers, and detent parts (if required) at this time. To verify operation prior to installation, shift through all gear selections and note turning torques.

IV. Half shaft repair procedures

(NOTE: Procedures for half shaft repair vary, depending on vehicle model. The technician should refer to a manual to obtain procedures appropriate for the vehicle to be serviced.)

A. Procedures for cleaning and inspecting a U-joint

1. Remove as much grease as possible from the joint to allow visual inspection.
2. Inspect joint housing raceways for wear.
3. Inspect all springs, cups, balls, and rollers for wear.
4. Inspect inner race or spider for wear.
5. Inspect axle shafts for bending or damaged splines.
6. Inspect rubber boots for cracks, tears, or worn spots.
7. Replace any components as required.

B. Procedure for disassembling the Rzeppa (double offset) joint

(NOTE: The Rzeppa joint is larger than most other universal joints. The Rzeppa can be identified by pulling back the boot and examining the joint. The Rzeppa will have a series of 6 steel ball bearings between the inner and outer races.)

1. Remove and discard the boot clamps.

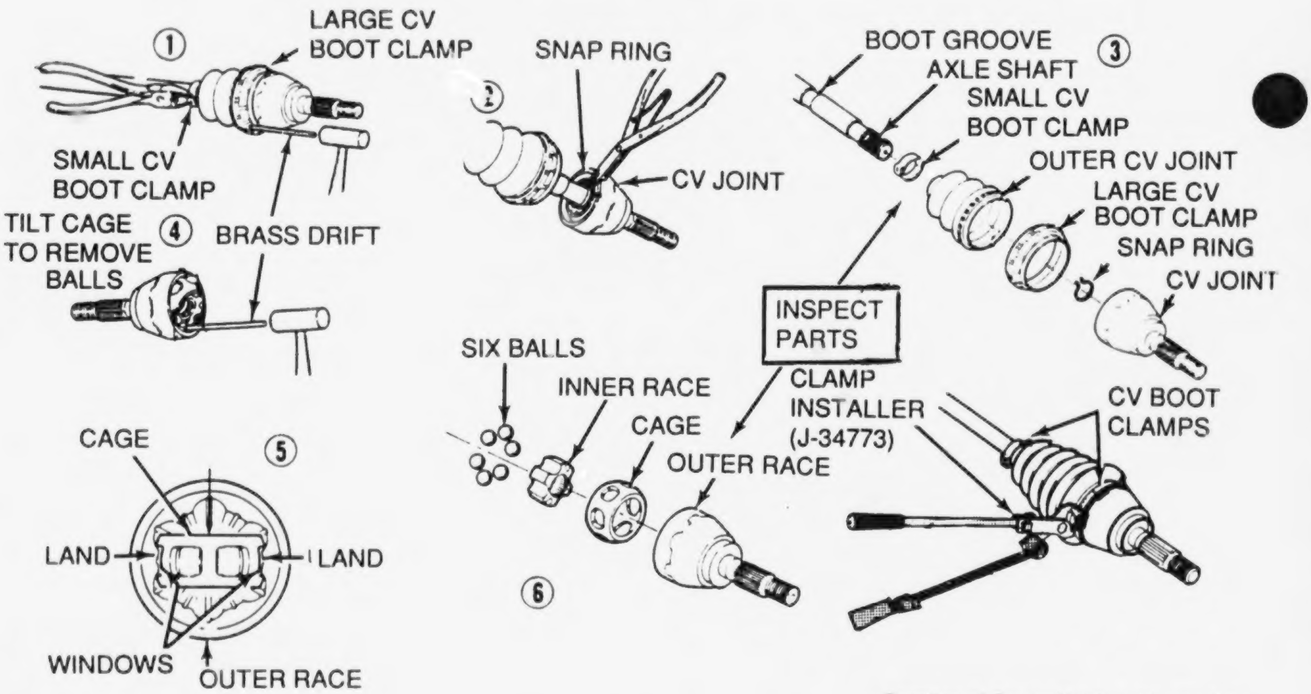
   (NOTE: On models equipped with anti-lock braking systems, a speed sensor ring will be a part of the outer joint. Extreme care must be taken to avoid damaging this ring. Refer to manufacturer's recommendations for service procedures.)

2. Pull back the boot and wipe off the excess grease. Slide the boot out of the way. It may be necessary to loosen and move a damper weight.

3. Remove retaining ring with snap ring pliers.

4. Remove steel balls. If necessary, tap gently on the inner race to tilt it.

5. Separate joint halves. Turn ball cage 1/4 of a turn so that its windows align with lands on the outer race. Remove ball cage.


①
LARGE CV BOOT CLAMP
SMALL CV BOOT CLAMP
BRASS DRIFT
②
SNAP RING
CV JOINT
③
BOOT GROOVE
AXLE SHAFT
SMALL CV BOOT CLAMP
OUTER CV JOINT
LARGE CV BOOT CLAMP
SNAP RING
CV JOINT
④
TILT CAGE TO REMOVE BALLS
INSPECT PARTS
⑤
CAGE
LAND
LAND
WINDOWS
OUTER RACE
⑥
SIX BALLS
INNER RACE
CAGE
OUTER RACE
CLAMP INSTALLER (J-34773)
CV BOOT CLAMPS

Courtesy of General Motors Corporation

C. Procedure for disassembling the tripod joint

(NOTE: The tripod joint is usually smaller than the Rzeppa. The tripod can be identified by pulling back the boot and examining the joint. The tripod joint will have three rollers on a center cross or "spider.")

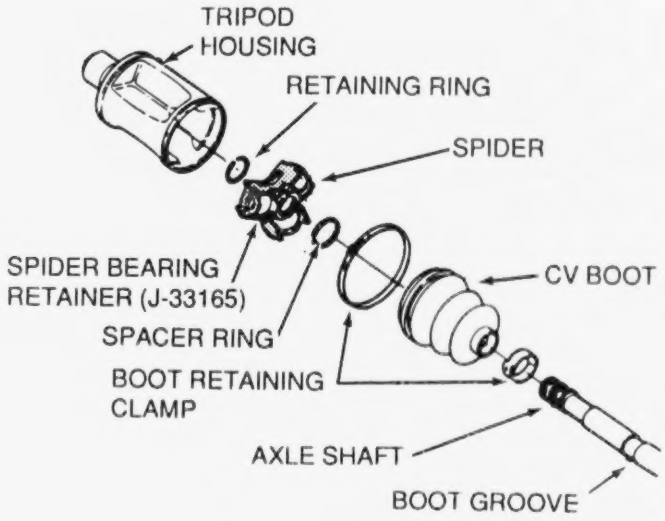
1. Remove and discard boot clamps.

2. Pull boot back and wipe off excess grease.

3. Remove tripod retaining ring or tabs.

4. Separate joint halves.

   (NOTE: Be sure to prevent the rollers and needle bearings from falling off the trunions of the center spider. If these rollers are not to be serviced, wrap them with tape. Remove snap rings and separate axle shafts from spider.)


TRIPOD HOUSING
RETAINING RING
SPIDER
SPIDER BEARING RETAINER (J-33165)
CV BOOT
SPACER RING
BOOT RETAINING CLAMP
AXLE SHAFT
BOOT GROOVE

Courtesy of General Motors Corporation

D. Joint reassembly

(NOTE: Manufacturers provide boot service packs, which contain the grease and straps needed for joint reassembly. Do not use grease other than that recommended by the manufacturer.)

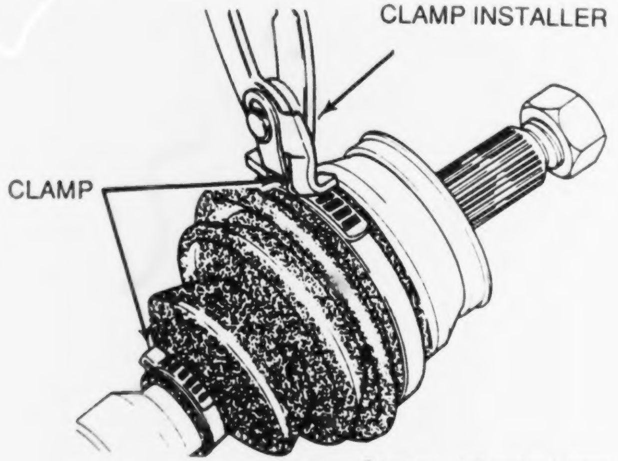
1. Reverse the disassembly procedures.

2. Twist and move joint through range of motion. The joint should not feel loose or be tightly bound.

3. Apply new grease from service pack.

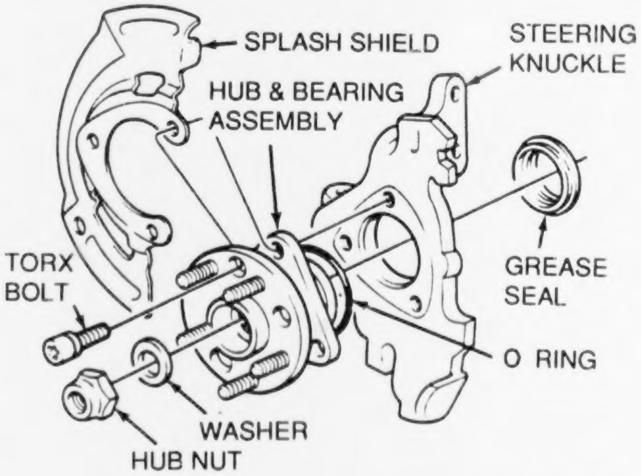
4. Slide boot into position. Use clamping tool to tighten and crimp new strap over the boot. It may be necessary to measure for correct location of boot.

   (**CAUTION:** Be careful not to cut through the clamp and damage the boot.)


CLAMP INSTALLER
CLAMP

Courtesy of Chrysler Motors

E. Spindle (steering knuckle) and hub service (on serviceable units)


SPLASH SHIELD
STEERING KNUCKLE
HUB & BEARING ASSEMBLY
TORX BOLT
GREASE SEAL
O RING
WASHER
HUB NUT

Courtesy of General Motors Corporation

1. Rotate hub and bearings by hand to check for roughness, looseness, or binding of wheel bearings.

2. If bearings are to be serviced, it will be necessary to use a special puller to remove the hub and bearing from the spindle. Refer to manual for correct procedures.

3. Clean and inspect bearings and races. Replace them if they are corroded, worn, scratched or burned.

4. Press out old races and press in new ones. New races must always be used with new bearings.

5. Pack wheel bearings with recommended grease.

6. Press hub and bearing assembly together with spindle. When doing so, make sure new grease seals are in place. Refer to manual for correct procedures.

   (NOTE: Spindle and hub units are nonserviceable. When the hub and bearing assembly on a nonserviceable unit are taken apart, the bearing is ruined and cannot be reused.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR INSPECTION AND DISASSEMBLY OF MANUAL TRANSAXLE COMPONENTS

Instructions: Do the following task on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the manual transaxle.
3. Determine and record critical dimensions or clearances of manual transaxle components. Develop a written procedure for checking each of these critical dimensions or clearances.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR MANUAL TRANSAXLE REASSEMBLY

Instructions: **Do the following task on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Determine and record all critical clearances that must be measured during manual transaxle reassembly. Develop a written procedure for checking each critical clearance.
3. Develop a procedure for reassembling the transmission.
4. Develop a procedure for reassembling the final drive.
5. Determine and record all torque specifications related to the manual transaxle.
6. Determine and record the type and quantity of fluid used to refill manual transaxle assembly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR HALF SHAFT AND CV JOINT SERVICE

Instructions: **Do the following task on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing a half shaft and CV joint.

   (NOTE: Identify any special tools needed to perform the procedure. Also include in the procedure instructions for positioning reference marks, if required.)
3. Develop a written procedure for disassembling the CV joint.
4. Explain how to lubricate a CV joint properly. Identify the type of lubricant to be used.
5. Develop a written procedure for reassembling a CV joint and half shaft.
6. Develop a written procedure for servicing a wheel bearing on a front-wheel-drive vehicle.
7. Develop a written procedure for replacing the wheel bearing on a front-wheel-drive vehicle.
8. Determine and record all torque specifications related to the half shaft and CV joints.
9. Develop a written procedure for installing a half shaft and CV joint in the vehicle.

   (NOTE: Be sure the procedure includes bleeding the brakes, if required.)

JS1-L2-UXI

MODULE: MANUAL DRIVE TRAIN AND AXLES

DISASSEMBLING, CLEANING, AND INSPECTING MANUAL TRANSAXLE COMPONENTS

Equipment:

Hand tools
Snap ring pliers
Drain pan
Special tool as outlined in AS1-L2-UXI
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Complete AS1-L2-UXI. — — — —

2. Wear safety glasses while doing all procedures on this job sheet. — — — —

3. Following the procedure developed in AS1-L2-UXI, inspect the transaxle for leakage. Record observations. — — — —

4. Complete AS1-L2-UXI. — — — —

5. Following the procedure developed in AS1-L2-UXI, drain the transmission fluid from the manual transaxle. Note the condition of the fluid. Record observations. — — — —

6. Using the procedure developed in AS1-L2-UXI, disassemble manual transmission. — — — —

7. Clean manual transaxle components and case. — — — —

   (NOTE: Clean transaxle components and case with safety solvent and blow dry.)

JS1-L2-UXI

8. Inspect all manual transaxle components for damage. Record results below. — — — —

(HINT: Refer to item 3 of AS1-L2-UXI for transmission specifications.)

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa2. Final evaluation for Aa2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Aa2 by averaging the final evaluations for JS1-L2-UIII, JS2-L2-UIII, JS1-L1-UXI and JS1-L2-UXI. Use the space provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UIII	—	—	—	—
JS2-L2-UIII	—	—	—	—
JS1-L1-UXI	—	—	—	—
JS1-L2-UXI	—	—	—	—
Final evaluation for Competency Aa2	—	—	—	—

MODULE: MANUAL DRIVE TRAIN AND AXLES

SERVICING THE CLUTCH ON A VEHICLE WITH A MANUAL TRANSAXLE

Equipment:

Hand tools
Hoist
Serviceable vehicle
Transmission jack
Torque wrench
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Place the car securely on safety stands or lift with hoist. __ __ __ __

   (**CAUTION:** Remove the negative battery cable before raising the vehicle.)

3. Remove the manual transaxle. __ __ __ __

4. Following the procedure outlined below, remove the clutch assembly. __ __ __ __

   a. Remove the clutch linkage.

   b. Remove the bellhousing.

   c. Mark the position of the pressure plate on the flywheel.

   d. Remove the pressure plate and clutch disc.

   e. Remove the flywheel.

5. Using the following checklist, clean and inspect clutch components. __ __ __ __

   Pilot bushing OK _____ NOT OK _____
   Flywheel OK _____ NOT OK _____
   Transmission input shaft collar OK _____ NOT OK _____
   Bell housing OK _____ NOT OK _____

   Ball stud and release fork OK _____ NOT OK _____
   Clutch disc OK _____ NOT OK _____
   Pressure plate OK _____ NOT OK _____
   Clutch linkage OK _____ NOT OK _____
   Throw-out bearing OK _____ NOT OK _____

For each component in item 5 that is NOT OK, explain the problem. Identify the steps that can be taken to correct the problem.

6. Following the procedure outlined below, replace the clutch assembly. __ __ __ __

a. Install the pilot bearing (if required).

b. Apply a thin coat of grease to:

Pilot bearing inner hole
Pilot end of transmission shaft
Input shaft collar
Throw-out bearing inner hole and fork groove

c. Install flywheel (if previously removed) and torque bolts to factory specifications.

d. Using a brake cleaner or other suitable solvents, remove grease from the surface of the flywheel and pressure plate.

e. Hold clutch disc in position with dummy input shaft or clutch alignment tool.

f. Install pressure plate. Moving from bolt to bolt in a diagonal pattern, tighten bolts gradually so that the pressure plate will be pulled down evenly. Torque bolts to factory specification.

(NOTE: If the same pressure plate is being reinstalled, it must be located in the same position as before.)

(NOTE: Use only bolts that are designed for flywheel and pressure plates.)

g. Adjust release fingers as required by the manufacturer.

h. Insert throw-out bearing into clips on release fork. Snap fork into position over bellhousing ball stud.

i. Remove dummy input shaft or alignment tool and install bellhousing and throw-out assembly. Torque bolts to specification.

j. Install guide studs in upper transmission holes on the bellhousing.

k. Adjust the clutch pedal free travel.

7. Reinstall and adjust the manual transaxle. — — — —

(NOTE: For this procedure, refer to JS1-L3-UXI.)

8. Clutch performance test. — — — —

a. Operate clutch pedal and note any squeaks or unusual noises. Recheck clutches that are not self-adjusting for proper free travel (approx. 1 inch).

b. After obtaining the instructor's approval, start vehicle while transmission is in low gear and the clutch pedal is depressed to the floorboard.

c. Gradually release the pedal until the vehicle begins to creep. Note any unusual noises. Friction point should occur when pedal is approximately halfway between the floorboard and the end of clutch pedal travel.

d. Turn off engine. Shift transmission into neutral and attempt to crank starter with clutch pedal up (clutch engaged).

e. Drive vehicle to verify that clutch engages smoothly. Note any unusual sounds or vibrations.

f. Recheck free play. Also, recheck clutch fluid and transmission lubricant.

(NOTE: Normal clutch operation will result in gradual wear of clutch disc facing. As the facing wears, movement of the pressure plate release fingers will reduce free travel of the clutch pedal. Clutches that are not self-adjusting will require adjustment of free travel.)

(NOTE: Fluid will occasionally have to be added to the master cylinder in hydraulic clutch assemblies.)

g. Record results of the clutch performance test.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency Z2. Final evaluation for Z2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Z2 by averaging the final evaluation of JS1-L2-UV and JS2-L2-UXI. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L2-UV	__	__	__	__
JS2-L2-UXI	__	__	__	__
Final evaluation for Competency Z2	__	__	__	__

MODULE: MANUAL DRIVE TRAINS AND AXLES

REASSEMBLING A MANUAL TRANSAXLE

Equipment:

Hand tools
Snap ring pliers
Special tools as outlined in AS2-L2-UXI
Torque wrench
Safety glasses

	Evaluation 3 2 1 N
Procedure:	
1. Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2. Following the procedure outlined below, reassemble the manual transaxle.	_ _ _ _

a. Be sure that all gasket material is completely removed from case, extension housing, side plate, and input shaft bearing retaining collar.

b. Be sure that all damaged or missing parts have been replaced as directed by the instructor.

c. Complete AS2-L2-UXI.

d. Using the procedure developed in AS2-L2-UXI, reassemble the manual transaxle.

(NOTE: Lightly coat all gears and bearings with appropriate fluid during reassembly.)

e. Bench test the manual transaxle to make sure that it works freely in all gears and shifts smoothly into all gears.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Aa3. Final evaluation for Competency Aa3 will be made at the end of JS1-L3-UXI.)

JS4-L2-UXI

MODULE: MANUAL DRIVE TRAIN AND AXLES

SERVICING A HALF SHAFT AND CV JOINT

Equipment:

Hand tools
Snap ring pliers
Special tools as outlined in AS3-L2-UXI
Torque wrench
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

3. Following the procedure outlined below, remove the half shaft and CV joints assembly from the vehicle. ___ ___ ___ ___

    a. Complete items 1 and 2 of AS3-L2-UXI.

    b. Using the procedure developed in item 2 of AS3-L2-UXI, remove the half shaft and CV joints from the vehicle.

4. Following the procedure outlined below, clean and service the CV joints. ___ ___ ___ ___

    (NOTE: Only service joints in need of repair.)

    a. Complete item 3 of AS3-L2-UXI.

    b. Using the procedure developed in item 3 of AS3-L2-UXI, disassemble the CV joint.

        (NOTE: Before disassembling the CV joint, obtain the instructor's approval. Not all CV joints should be taken completely apart.)

    c. Clean the CV joint with safety solvent and blow dry.

d. Inspect the CV joint for signs of wear. Record observations.

e. Complete items 4 and 5 of AS3-L2-UXI.

f. Replace all worn parts.

g. Using the procedure developed in items 4 and 5 of AS3-L2-UXI, lubricate and reassemble the CV joint and half shaft.

5. Following the procedure outlined below, inspect and service the hub and wheel bearings.

— — — —

a. Rotate hub and bearing by hand to check for roughness, looseness, or binding of the wheel bearing. Record observations.

b. Refer to manufacturer's service manual to determine if the wheel bearing is serviceable.

Is the wheel serviceable?

Yes _____ No _____

If yes, complete item 6 of AS3-L2-UXI.

If no, and the wheel bearing needs to be replaced, complete item 7 of AS3-L2-UXI.

If no, and the wheel bearing does not need to be replaced, proceed to step 6 of this job sheet.

c. Using the procedure developed in either items 6 or 7 of AS3-L2-UXI, service or replace the wheel bearing.

d. Inspect the grease seals and replace as needed.

6. Following the procedure outlined below, install the half shaft and CV joints in the vehicle. — — — —

a. Complete items 8 and 9 of AS3-L2-UXI.

b. Following the procedure developed in items 8 and 9 of AS3-L2-UXI, install the half shaft and CV joints in the vehicle.

(**CAUTION:** Most manufacturers require that the old spindle be replaced with a new one each time the old spindle is removed.)

(**CAUTION:** Make sure the brakes are working properly before trying to move the vehicle.)

Average of above evaluations* — — — —

(*This average is the final evaluation for Competency Bb2.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

LESSON 3: TRANSAXLE INSTALLATION AND PERFORMANCE TESTING

I. Manufacturers state that, in general, procedures for installing a manual transaxle should simply be the reverse of removal procedures. Transaxle installation, however, may require some procedures not used during transaxle removal.

   A. Engaging the input shaft splines with the clutch disc may be difficult. The input shaft must be turned so that the splines will line up exactly. Never force the transaxle into position or allow it to hang by the input shaft. Doing so can result in damage to or misalignment of the clutch disc. A pilot stud threaded into the engine block may simplify installation of the transaxle.

   B. Bolts should be torqued to factory specifications.

   C. Old cotter pins must always be replaced with new ones.

   D. The manual transaxle must be filled to the correct level with the proper type of lubricant--usually an automatic transmission fluid. Refer to the manufacturer's specifications for level and type.

   E. Shift linkages and clutch linkages adjustments are usually made after installation of the transaxle.

   (NOTE: Adjustment procedures vary widely, depending upon vehicle model. The technician should refer to a manual to obtain correct procedures for the vehicle to be serviced.)

   F. Refill hydraulic clutch master cylinder.

II. Procedures for performance testing the transaxle.

   A. Test brake assembly using the procedure outlined below.

   (NOTE: Because brake calipers are always removed along with the transaxle, the braking system must be tested before any other components.)

      1. Pump the brake pedal several times.

      2. Press firmly and note pedal travel. The pedal should feel firm.

   B. Test shifter operation by moving shift lever through all gear positions. Note any malfunctions.

   C. Test clutch operation using the procedure outlined below.

      1. Start engine (with the instructor's approval and supervision).

      2. Depress clutch pedal and note any unusual noises.

3. Shift into gear and slowly release pedal. Check for location of friction point. Friction point should be reached when pedal is approximately halfway off the floor. Refer to manual for correct adjustment procedures if required.

4. Check under vehicle for dripping fluids. Make repairs as required.

D. Test drive the vehicle using the procedure outlined below.

(NOTE: Be sure to consult with instructor before test driving any vehicle.)

1. Drive vehicle a short distance under light load at low speed.

2. Note any unusual noises or vibrations. Refer to diagnosis information as required.

3. Park vehicle and look underneath for fluid loss. Make repairs as necessary.

4. Drive vehicle normally both at low speeds and highway speeds. Note any unusual noises and vibrations. Make repairs as required.

5. Return to shop. Check vehicle for fluid leaks once again.

MODULE: MANUAL DRIVE TRAIN AND AXLES

REINSTALLING A MANUAL TRANSAXLE

Instructions: Do the following task on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for reinstalling a manual transaxle. Include appropriate torque specifications.
3. Develop a written procedure for adjusting the linkage.
4. Develop a written procedure for aligning power train mounts.

JS1-L3-UXI

MODULE: MANUAL DRIVE TRAIN AND AXLES

REINSTALLING AND ADJUSTING A MANUAL TRANSAXLE

Equipment:

Hand tools
Hoist
Service light
Transmission jack
Torque wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Complete AS1-L3-UXI. ___ ___ ___ ___

2. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

3. Place the car securely on safety stands or lift with hoist. ___ ___ ___ ___

4. Follow the procedure outlined below to reinstall the manual transmission. ___ ___ ___ ___

    a. Using the procedure developed in AS1-L3-UXI, reinstall the manual transaxle.

    b. Torque to specification mounting bolts and linkage mounting bolts as required in service manual.

    c. Install half shafts.

    d. Fill manual transaxle with fluid to the correct level.

    (**CAUTION:** Make sure the differential and transmission are both filled to the proper level.)

    e. Adjust (center) shift linkage.

    f. Align power train mounts.

5. Following the procedure outlined in JS1-L2-UX, test the adjustment of the shift linkage and the operation of the manual transaxle. Record observations. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Aa3. Final evaluation will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Aa3 by averaging the final evaluation of JS1-L3-UIII, JS2-L3-UIII, JS3-L2-UXI, and JS1-L3-UXI. Use the spaces provided below.

JS1-L3-UIII — — — —

JS2-L3-UIII — — — —

JS3-L2-UXI — — — —

JS1-L3-UXI — — — —

Final evaluation for Competency Aa3 — — — —

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XI: MANUAL TRANSAXLE REPAIR, INSTALLATION, AND PERFORMANCE TESTING

UNIT XI TEST

PART I. REMOVING AND DISASSEMBLING THE TRANSAXLE

SECTION A. **Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.**

____ 1. Improperly raising a vehicle with a manual transaxle can bend the rear dead axle and cause other damage to the underside of the vehicle.

____ 2. In front-wheel-drive vehicles, the manual transaxle provides part of the support for the engine.

____ 3. Unless it is damaged, the speedometer cable should remain attached to the transaxle when the transaxle is removed.

____ 4. When disconnecting half shafts from front hubs on vehicles with manual transaxles, it may be necessary to separate the lower ball joint or unbolt the spindle.

____ 5. During manual transaxle removal, the vehicle should be raised just enough to take the weight off the mounts after the engine holding fixture is installed.

____ 6. When removing a manual transaxle from most vehicles, the shift rail detent system and reverse idler shafts should be removed last.

____ 7. Manual transaxle seals should be cleaned in solvent.

____ 8. Shafts and gears from manual transaxle vehicles should be cleaned in solvent.

____ 9. The reverse idler gear is unsynchronized on vehicles with a manual transaxle. The reverse idler gear can be expected to show some clash damage during inspection.

____ 10. The adjustment of the clutch on vehicles with manual transaxles can be done without removing the transaxle.

(NOTE: The student must obtain a minimum score of ______ on Part I of the Unit XI Test in order to receive an evaluation for Competencies Aa2 and Z2.)

PART II. REPAIRING, INSTALLING, AND PERFORMANCE TESTING THE TRANSAXLE

SECTION A. Select the best answer from the five choices listed.

____ 11. The adjustments required on manual transaxle assemblies are, in general, less complicated than those required on rear-wheel-drive differentials. Adjustments on manual transaxle assemblies are easier because, in the transaxle, the drive pinion gear (output gear) and ring gear

a. operate at a 20-degree angle to the main shaft.
b. operate at a 90-degree angle to the main shaft.
c. both operate horizontally.
d. operate in intersecting axis lines.
e. operate in parallel axis lines.

____ 12. In vehicles with manual transaxles, the preload against the input shaft bearings, output shaft bearings, and differential bearings is usually adjusted by

a. slightly adjusting drive shaft height.
b. slightly adjusting input shaft angles.
c. slightly adjusting the clutch fork.
d. doing all of the above.
e. doing none of the above.

____ 13. On vehicles with manual transaxles, the end play clearance between gears and hubs is usually measured with

a. calipers.
b. a micrometer.
c. a telescoping gauge.
d. a spacer bar.
e. none of the above.

____ 14. Compared to other constant velocity joints, the Rzeppa joint is

a. larger.
b. about the same size.
c. smaller.
d. narrower.
e. lighter.

____ 15. Compared to the Rzeppa joint, the tripod joint is

a. larger.
b. about the same size.
c. smaller.
d. more oblong in shape.
e. more rectangular in shape.

____ 16. Both the Rzeppa and the tripod joint can be identified by

a. locating a code engraved on the joint.
b. noting the external shape of the joint.
c. pulling back the boot and examining the joint.
d. noting the number of boot clamps each joint uses.
e. none of the above methods.

____ 17. When reassembling a constant velocity joint, the technician should lubricate the joint with

a. axle grease.
b. bearing grease.
c. grease provided in the boot service pack.
d. a very light grease.
e. none of the above.

____ 18. During spindle (steering knuckle) and hub service, races should be replaced

a. only if they exhibit significant wear.
b. if they exhibit any wear whatsoever.
c. at the same time bearings are replaced regardless of the condition of the races.
d. only if they will not function properly with the replacement bearings.
e. if the vehicle has over 50,000 miles on the odometer.

SECTION B. **Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.**

____ 19. Manufacturers state that, in general, procedures for installing the manual transaxle should simply be the reverse of removal procedures.

____ 20. When installing a manual transaxle, old cotter pins can be used if they are not damaged.

____ 21. Adjustments usually must be made to shift linkages and clutch linkages before installing the manual transaxle.

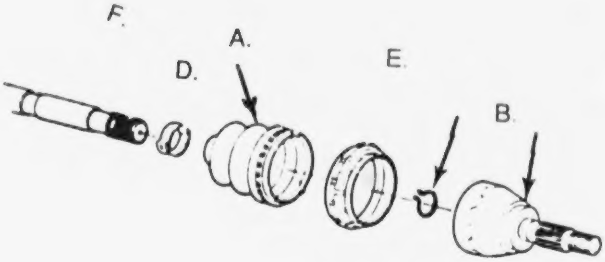
____ 22. Brake calipers must be removed along with the manual transaxle only on vehicles with anti-lock brake systems.

____ 23. During a performance test of the clutch (in a vehicle with a newly installed manual transaxle), the friction point should occur when pedal is approximately halfway off the floor.

____ 24. During a test drive of a vehicle with a newly installed manual transaxle, the vehicle should first be driven a short distance under a light load.

____ 25. During the second test drive of a vehicle with a newly installed manual transaxle, the vehicle should be driven hard in a low gear to determine if the transaxle can handle high torque demands.

SECTION C. Shown below are several components of a half shaft. Place the letter of each component in the blank beside the component's name.



____ 26. Snap ring

____ 27. CV boot

____ 28. CV joint

(NOTE: The student must obtain a minimum score of ______ on Part II of the Unit XI Test in order to receive an evaluation for Competencies Aa3 and Bb2.)

ANSWERS TO UNIT TEST XI

1. t
2. t
3. f
4. t
5. t
6. f
7. f
8. t
9. t
10. f
11. e
12. e
13. e
14. a
15. c
16. c
17. c
18. c
19. t
20. f
21. f
22. f
23. t
24. t
25. f
26. c
27. a
28. b

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student will be able to identify the basic principles of four-wheel-drive operation and the basic procedures for diagnosing and repairing four-wheel-drive vehicles. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student will be able to:

Lesson 1. I. Identify terms and definitions associated with four-wheel-drive operation (Competencies Dd1-Dd6, Unit XII Test).

II. Identify four-wheel-drive components and the principles by which they function (Competencies Dd1-Dd6, Unit XII Test).

III. Describe driveline operation in four-wheel-drive vehicles (Competencies Dd1-Dd6, Unit XII Test).

Lesson 2. I. Identify safety principles for diagnosing and repairing four-wheel-drive vehicles (Competencies Dd1-Dd6, Unit XII Test).

II. Identify procedures for diagnosing a four-wheel-drive vehicle (Competencies Dd1-Dd6, Unit XII Test).

III. Identify repair procedures for front locking hubs (Competencies Dd4-Dd6, Unit XII Test).

IV. Identify procedures for removing the front differential assembly (Competencies Dd1, Dd4, Dd5, and Dd6, Unit XII Test).

V. Identify service procedures for front spindles (Competencies Dd4-Dd6, Unit XII Test).

VI. Demonstrate the ability to:

a. Diagnose and determine needed repairs for a four-wheel-drive system (Competencies Dd1 and Dd4, JS1-L2-UXII).

b. Service hub, wheel bearings, and universal joints on four-wheel-drive vehicles (Competencies Dd5 and Dd6, JS2-L2-UXII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks C072, C076-C079.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

    1. Lesson 1: FOUR-WHEEL-DRIVE COMPONENTS AND OPERATION

        a. Information outline

    2. Lesson 2: FOUR-WHEEL-DRIVE DIAGNOSIS AND REPAIR

        a. Information outline

        b. Assignment sheets

            AS1-L2-UXII: Procedure for Servicing Hubs and Wheel Bearings on Four-Wheel-Drive Vehicles

            AS2-L2-UXII: Procedure for Drive Shaft and Universal Joint Service

        c. Job sheets

            JS1-L2-UXII: Diagnosing and Determining Needed Repairs for Four-Wheel-Drive Systems

            JS2-L2-UXII: Servicing Hubs, Wheel Bearings, and Universal Joints on Four-Wheel-Drive Vehicles

E. Unit test

F. Answers to unit test

REFERENCES

Crouse, William H. Automotive Mechanics. 8th ed. New York: McGraw-Hill Book Company, 1980.

Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should perform AS1-L2-UXII and AS2-L2-UXII in conjunction with JS2-L2-UXII.

2. JS2-L2-UXII outlines two separate procedures for servicing four-wheel-drive vehicles. Item 2 of JS2-L2-UXII outlines the procedure for servicing hubs and wheel bearings. Item 3 of JS2-L2-UXII outlines the procedure for servicing drive shafts and universal joints. The student should only perform the procedure that is appropriate for the vehicle to be serviced. It is, of course, appropriate for the student to perform both procedures if necessary.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.

2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.

3. The Principles of the Differential (AM-84-450), 1984.

4. Axle Bearing and Seal Replacement (AM-84-452), 1984.

5. Servicing and Repair of Front-Wheel Drive Axles (AM-86-602), 1986.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR

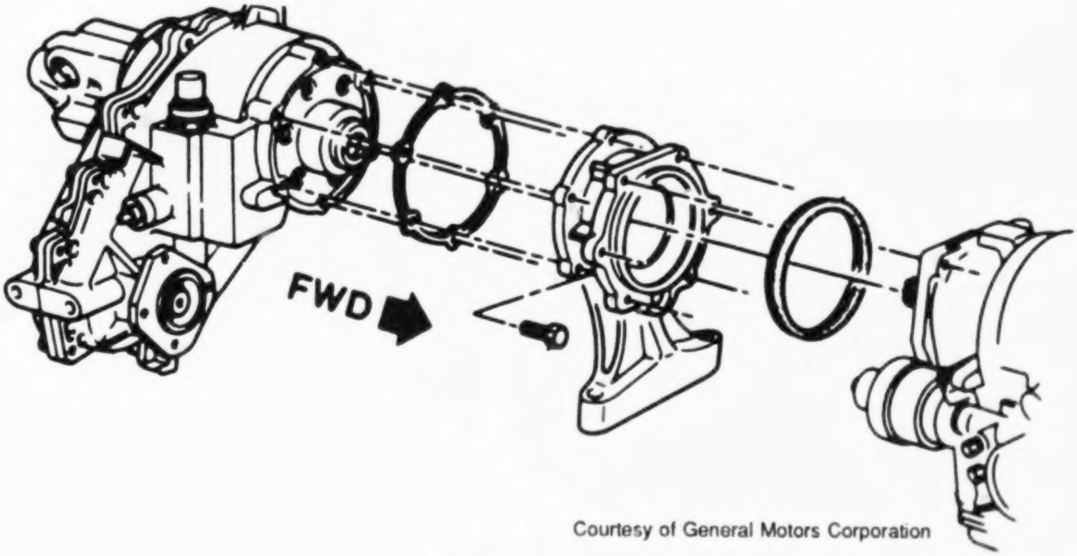
LESSON 1: FOUR-WHEEL-DRIVE COMPONENTS AND OPERATION

I. Terms and definitions

- A. Kingpin--A large steel pin on which a steering spindle (knuckle) turns in order to steer a vehicle.
- B. Locking hub--A type of front hub that can either be locked to a driving axle shaft in order to receive turning power or unlocked to allow the hub and wheel to spin without turning the axle shaft. The locking hub may be manually or electrically operated. The hub may also be designed to lock automatically on acceleration.
- C. Low range--A mode of operation (on a four-wheel-drive vehicle) in which the driving ratio is lower than normal. Low range allows the vehicle more pulling power. Changes in driving ratio are made inside the transfer case.
- D. Transfer case--A gearbox that is connected to the transmission output shaft. The transfer case relays the turning power to either the rear differential or both the rear and front differentials. One or more of the lower gear ratios (in addition to the direct drive ratio) is usually made available through various gear engagements inside the transfer case.

II. Four-wheel-drive components and functions

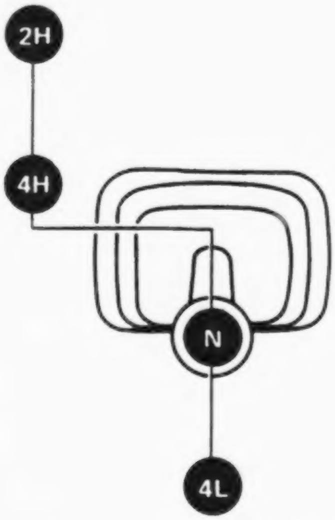
- A. Transfer case
  - 1. The transfer case usually bolts directly to the rear of the transmission.



Courtesy of General Motors Corporation

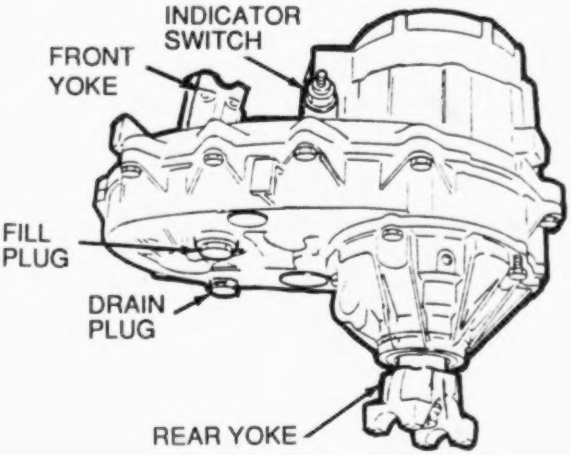
2. Shift linkage from the transfer case connects to a range-selection shifter inside the vehicle interior.

3. The range-selection shifter enables the driver to choose between two-wheel-drive (rear-drive) and four-wheel-drive operation. The range-selection shifter also enables the driver to choose between one-gear range and direct-drive range.



Courtesy of General Motors Corporation

4. A yoke at the rear of the case joins with the front U-joint of the rear differential drive shaft.


INDICATOR SWITCH
FRONT YOKE
FILL PLUG
DRAIN PLUG
REAR YOKE

5. A yoke at the front of the case joins with the front U-joint of the front differential drive shaft.

    (NOTE: Detailed information concerning transfer case components and their operation appears in Unit XIII, Transfer Case Diagnosis and Repair.)

B. Drive shafts

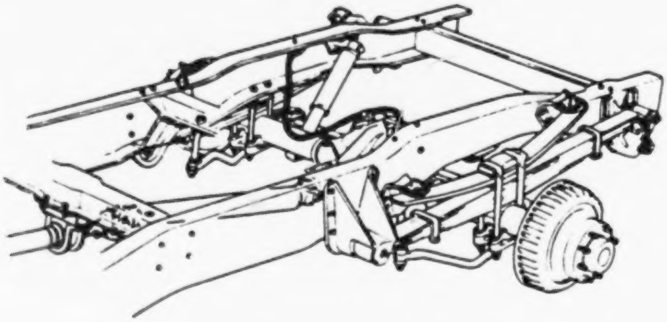
1. A drive shaft with conventional type U-joints connects the transfer case to the rear differential.

2. A drive shaft with conventional cardan U-joints connects the transfer case to the front differential.

C. Rear differential

1. The rear differential on four-wheel-drive vehicles is identical in operation to differentials in conventional rear-wheel-drive vehicles.

2. Heavy-duty, four-wheel-drive vehicles use 3/4-floating or full-floating hub and axle designs.



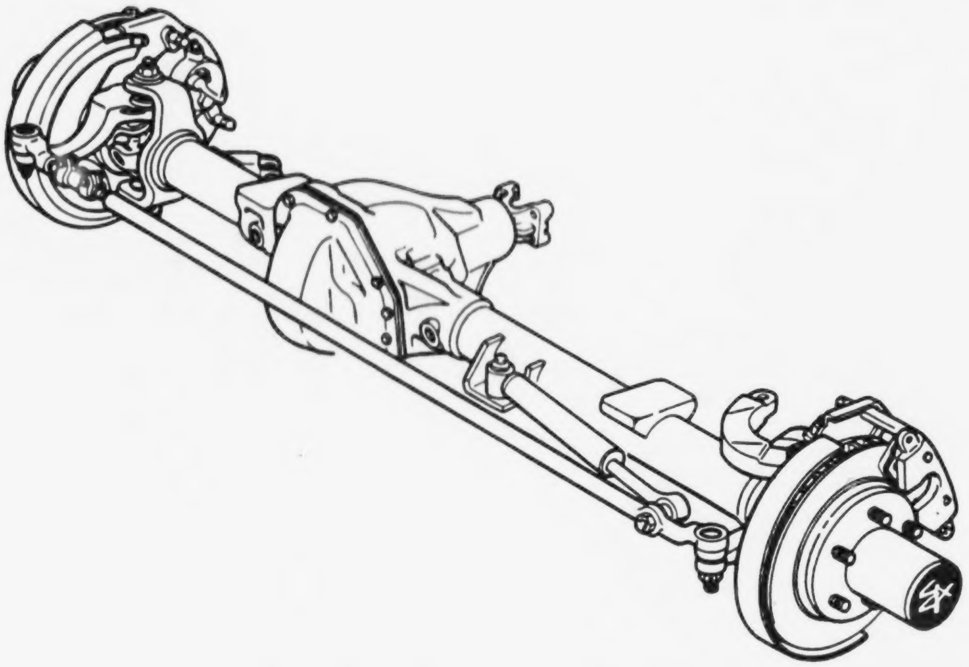
Courtesy of General Motors Corporation

D. Front differential

1. The front differential is identical in operation to differentials in conventional rear-wheel-drive vehicles.

2. The axles of the front differential can be straight with rigid tubes or they can contain U-joints for independent front suspension.

3. Straight front axle assemblies use ball joints at the ends of the axle tubes to provide for front steering. A U-joint at this location allows the front spindles (knuckles) to turn.



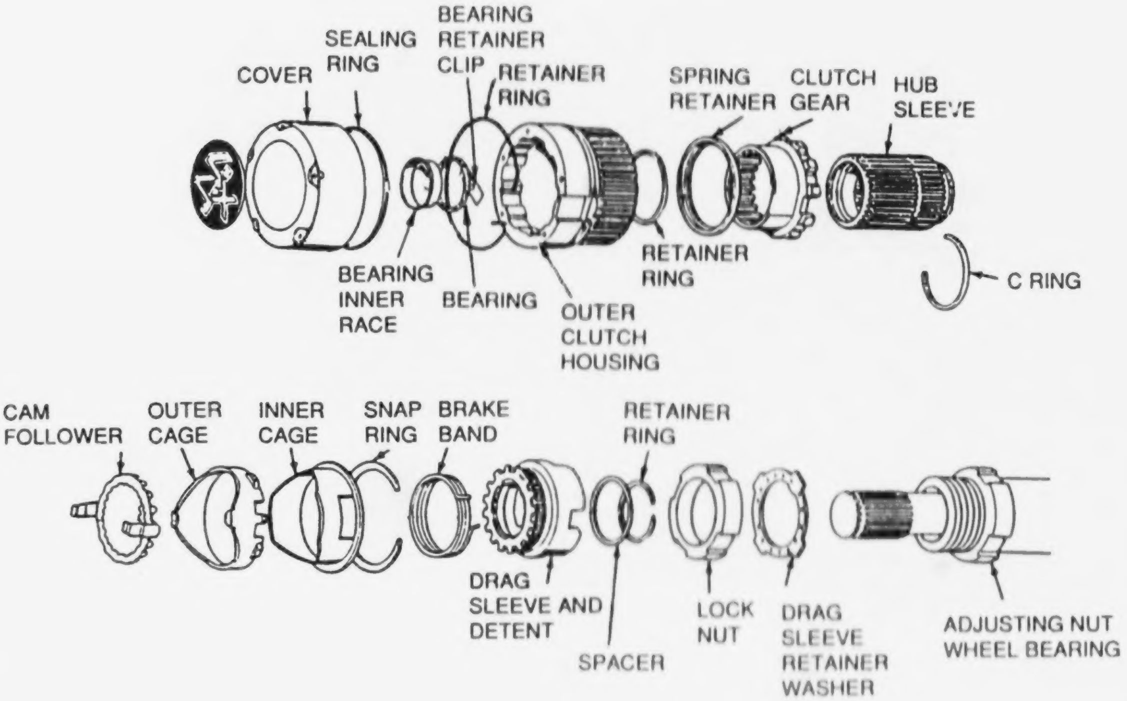
Courtesy of General Motors Corporation

4. Independent front-axle suspension systems use either swing axles (twin I-beams) or long/short arm suspension with ball joints connected to spindles (steering knuckles).

5. Front differentials usually use coil springs but they can use leaf springs as well.

E. Front hubs

1. The front hubs are internally splined to connect with the front drive axle.
2. The hubs rotate on inward-facing, tapered roller bearings.
3. A locking mechanism in the hubs ensures that the front drive shafts and differential components are not turned during two-wheel-drive operation. The locking mechanism, therefore, reduces front driveline wear and drag, and reduces fuel consumption.


COVER
SEALING RING
BEARING RETAINER CLIP
RETAINER RING
SPRING RETAINER
CLUTCH GEAR
HUB SLEEVE
BEARING INNER RACE
BEARING
OUTER CLUTCH HOUSING
RETAINER RING
C RING
CAM FOLLOWER
OUTER CAGE
INNER CAGE
SNAP RING
BRAKE BAND
RETAINER RING
DRAG SLEEVE AND DETENT
SPACER
LOCK NUT
DRAG SLEEVE RETAINER WASHER
ADJUSTING NUT WHEEL BEARING

Courtesy of General Motors Corporation

4. The locking mechanisms are operated either manually (by turning a knob on each hub), electrically, or automatically (by way of a centrifugal overrunning clutch).

III. Driveline operation

A. Description of two-wheel-drive operation

1. The driver moves the transfer case lever to the two-wheel-drive position. In many cases, the vehicle must be stopped in order to change operating modes safely. Refer to the owner's manual for procedures.

2. Gears inside the transfer case transfer driving power from the transmission output shaft to the rear differential drive shaft yoke at a 1 to 1 ratio.

3. The front locking hubs should be unlocked if they are manually operated.

4. The drive shaft relays the turning power to the rear differential, which operates exactly like a rear differential in a rear-wheel-drive vehicle (see Unit VIII for review).

5. The transfer case does not turn the front differential or drive shafts.

B. Description of four-wheel-drive operation (high range)

1. The vehicle operator moves the transfer case lever to the four-wheel-drive position. Usually the vehicle must be stopped in order to change operating modes safely. Refer to the owner's manual for procedures.

2. Gears inside the transfer case transfer the driving power to both the rear and front differential drive shafts at a 1 to 1 ratio.

3. Manually operated front hubs must be locked to the axles before operating the vehicle in four-wheel-drive. On vehicles with centrifugal overrunning clutches, this lockup occurs automatically when the front axles begin to turn faster than the hubs and front wheels. If the wheels and hubs begin to turn faster than the axles, the overrunning clutch prevents the axles, the drive shaft, and the front differential from being turned.

4. When operating in four-wheel-drive, the transfer case turns both the front and rear drive shafts.

5. Both the front and rear differentials operate exactly the same as those in a rear-wheel-drive vehicle (see Unit VIII for review).

C. Description of four-wheel-drive operation (low range)

1. The driver moves the transfer case lever to the four-wheel-drive low-range position. In many cases, the vehicle must be stopped in order to change operating modes safely. Refer to the owner's manual for procedures.

2. The gears inside the transfer case transfer driving power to both the rear and front differential drive shafts in a lower gear ratio (higher than 1 to 1).

(NOTE: All other low-range operations are the same as four-wheel-drive, high-range operations.)

3. Manually operated front hubs must be locked to the axles before operating the vehicle in four-wheel-drive. On vehicles with centrifugal overrunning clutches, this lockup occurs automatically when the front axles begin to turn faster than the hubs and front wheels. If the wheels and hubs begin to turn faster than the axles, the overrunning clutch prevents the axles, the drive shaft, and the front differential from being turned.

4. The transfer case turns both the front and rear drive shafts.

5. Both the front and rear differentials operate exactly the same as those in a rear-wheel-drive vehicle (see Unit VIII for review).

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR

LESSON 2: FOUR-WHEEL-DRIVE DIAGNOSIS AND REPAIR

(NOTE: Diagnosis and repair of transfer cases will be covered in Unit XIII, "Transfer Case Diagnosis and Repair.")

I. Safety in four-wheel-drive diagnosis and repair

   A. Never test drive a vehicle without the instructor's approval and supervision.

   B. Never attempt to test drive a vehicle with the doors open. Never attempt to listen underneath a moving vehicle.

   C. Four-wheel-drive vehicles can be especially difficult to raise properly on a lift rack. Attempt to do so only with the instructor's supervision.

      1. Stay clear of hot exhaust components. A catalytic converter can reach a temperature of more than 1000°F.

      2. Stay clear of moving parts when a vehicle is on the lift rack. Long hair or loose clothing can easily become entangled in moving parts.

      3. Wear protective clothing and safety goggles when working under a vehicle.

      4. Ventilate exhaust fumes to the outdoors.

      5. Never attempt to engage cruise control while the vehicle is on a lift rack or jackstands.

   D. Never crawl underneath a vehicle that is supported only by a jack. Refer to manufacturer's recommendations for jack and jackstand locations.

II. Procedures for diagnosing a four-wheel-drive vehicle

   A. If the vehicle makes a clanking sound while moving (in two-wheel-drive operation only), follow the diagnostic procedures outlined below.

      1. Inspect engine and transmission mounts for looseness.

      2. Inspect differential mountings and bearings for looseness.

      3. Check for clutch and transmission problems. See Units III and VI for procedures.

      4. While the vehicle is supported on a lift rack or jackstands with the engine off, grasp the rear drive shaft and check for excessively loose U-joints or differential. See Units VII and IX for procedures.

B. If the vehicle makes a clanking sound upon moving (in four-wheel-drive operation only), follow the diagnostic procedures outlined below.

1. Inspect engine, transmission, and transfer case mounts for looseness.
2. Inspect front differential mountings for looseness.
3. While the vehicle is supported on a lift rack or jackstands with the engine off, grasp the front drive shaft and check for excessively loose U-joints, differentials, and drive axle U-joints. See Units VII and IX for procedures.

C. If the vehicle clicks or squeaks when backing, follow the diagnostic procedure outlined below.

1. Make sure the clicks and squeaks are not coming from the hub caps. Rocks or loose parts in the hub caps can sound like U-joint problems.
2. Check for excessive play in wheel bearings.
3. Remove drive shafts and check U-joints for binding. See Unit VII for repair procedures.

D. If there is roughness or vibration during vehicle operation, follow the diagnostic procedure outlined below.

(NOTE: Tire runout and imbalance can cause roughness and vibration during vehicle operation. If roughness or vibration is due to a bent drive shaft or defective U-joint, the problem will be more pronounced when the vehicle is under a load. Such vibrations generally begin at about 35-45 mph and may improve or worsen at higher speeds.)

1. Determine which drive shafts are causing the vibration by driving in both the two-wheel-drive and four-wheel-drive mode. Vibration occurring only during two-wheel-drive operation indicates a rear drive shaft problem. Vibration occurring only during four-wheel-drive operation indicates front drive shaft problems.
2. Check for drive shaft imbalance due to mud or undercoating.
3. Check for drive shaft imbalance due to bent shaft or lost balance weights.
4. Check for excessively loose or tight drive shaft U-bolts.
5. Check for improper location of the U-joint in the companion flange.
6. Check for an excessively loose or tight U-joint.
7. Check for looseness at slip yoke bushings.
8. Check for companion flange imbalance or run out.

E. If the vehicle will not operate in any mode, follow the diagnostic procedure outlined below.

  1. Check clutch and transmission. See Units III and VI for procedures.

  2. Check transfer case operation. See Unit XIII for procedures.

F. If the vehicle will operate in the two-wheel-drive mode only, follow the diagnostic procedures outlined below.

  1. Check for locking of front hubs.

  2. Check for broken front drive shaft or differential.

  3. Check transfer case operation. See Unit XIII for procedures.

G. If the vehicle will operate in all modes except low-range four-wheel-drive, check transfer case. See Unit XIII for procedures.

III. Locking hub designs vary greatly, depending on vehicle model. Repair procedures for front locking hubs, therefore, cannot be generalized. Refer to an appropriate manual for correct tools and procedures for repair.

IV. Procedures for removing the front differential assembly (typical)

(NOTE: The front differential assembly can weigh several hundred pounds. Careful consideration must be given to the handling of the front differential. Consult with the instructor for procedures.)

A. Raise front of vehicle until weight is removed from front springs. Support behind front springs on jackstands.

B. Disconnect the drive shaft from the front differential.

C. Disconnect steering linkage.

D. Remove brake lines on drum brake systems. On disc brake systems, remove caliper and suspend it with wire.

E. Disconnect shock absorbers.

F. For procedures on disconnecting drive axles from spindles (steering knuckles) on vehicles equipped with coil springs, refer to an appropriate manual.

G. Disconnect any brake lines, wires, or vent hoses from the differential.

H. Remove U-bolts that hold the axle tubes to springs on vehicles with leaf springs.

I. Raise vehicle to clear differential assembly and roll assembly out from under vehicle.

V. Front spindle designs vary greatly, depending on vehicle model. Repair procedures for front spindles, therefore, cannot be generalized. Refer to an appropriate manual for correct tools and procedures for repair.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR SERVICING HUBS AND WHEEL BEARINGS ON FOUR-WHEEL-DRIVE VEHICLES

Instructions: Do the following task on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. Develop a written procedure for disassembling the hub and wheel bearings.

3. Explain how to pack the wheel bearings and identify the type of grease that will be used.

4. Develop a written procedure for reassembling the hubs and wheel bearings.

   (NOTE: The procedure should also include torque specifications.)

5. Determine and record the critical dimensions or clearances relating to hub and wheel bearings. Develop a written procedure for checking each critical dimension or clearance.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR DRIVE SHAFT AND UNIVERSAL JOINT SERVICE

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the drive shaft.
3. Develop a written procedure for installing the drive shaft.

JS1-L2-UXII

MODULE: MANUAL DRIVE TRAIN AND AXLES

DIAGNOSING AND DETERMINING NEEDED REPAIRS FOR FOUR-WHEEL-DRIVE SYSTEMS

Equipment:

Hand tools
Hoist
Service light
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine the condition of the four-wheel-drive assembly. __ __ __ __

   a. Check the condition of the clutch. Refer to JS1-L2-UV for the proper procedure. Record observations.

   b. Does the four-wheel-drive assembly have any of the following problems?

      Low fluid level
      Worn linkage
      Bent linkage
      Loose transmission bolts
      Loose ball housing bolts
      Binding or sticking clutch peddle

      Yes _____ No _____

c. If the four-wheel-drive system has any of the problems listed in item "b" above, give details about the problem and recommend repair procedures.

3. Following the procedure outlined below, performance test a vehicle equipped with a four-wheel-drive transfer case. — — — —

   (NOTE: For a more complete discussion of diagnosing a transfer case, see Unit XIII of this module.)

   a. Start vehicle (with the instructor's approval) and drive slowly in each of the transfer case gear ranges. Note any grinding, grabbing, slipping, or other unusual activity or noise. Record observations.

   b. According to the performance test, is the four-wheel-drive system operating properly?

      Yes ______ No ______

   c. If no, explain steps that should be taken to correct the situation.

4. Following the procedure outlined below, diagnose drive shaft and universal joint problems. — — — —

   a. Inspect differential control arms and bushings for looseness.

   b. Rotate drive shaft back and forth while observing the movement between the yokes.

   c. Inspect the drive shaft carrier bearing.

   d. Record observations.

e. Are the drive shaft and universal joints ok?

Yes ______ No ______

f. If no, recommend steps that can be taken to correct the problem.

(NOTE: For drive shaft and universal joint service, refer to JS2-L2-UXII.)

5. Following the procedure outlined below, determine the condition of the hubs and wheel bearings.

   a. Place the car securely on safety stands or lift with hoist.

   b. Check to make sure hubs will lock and unlock. Record results.

   c. Rock each wheel and check the wheel bearing adjustment. Record observations.

   d. Rotate each wheel by hand in the "hub-unlocked" position to verify that it will rotate freely. Check for roughness, looseness, or binding of the wheel bearing. Record observations.

e. According to this test, are the hubs and wheel bearings in good condition?

Yes ______ No ______

f. If no, recommend steps that can be taken to correct the problem.

(NOTE: For hub and wheel bearing service, refer to JS2-L2-UXII.)

(NOTE: For differential service, refer to units II and III.)

Average of above evaluations* _ _ _ _

(*This average is the final evaluation for Competency Dd4 and a partial evaluation for Competency Dd1. Final evaluation for Dd1 will be made at JS1-L4-UXIII.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

SERVICING HUBS, WHEEL BEARINGS, AND UNIVERSAL JOINTS ON FOUR-WHEEL-DRIVE VEHICLES

Equipment:

Hand tools
Snap ring pliers
Drain pan
Special tools identified in AS1-L2-UXII and AS2-L2-UXII
Safety glasses

(NOTE: JS2-L2-UXII outlines two separate procedures for servicing four-wheel-drive vehicles. Item 2 of JS2-L2-UXII outlines the procedure for servicing hubs and wheel bearings. Item 3 of JS2-L2-UXII outlines the procedure for servicing drive shafts and universal joints. Perform only the procedure that is appropriate for the vehicle to be serviced. It is, of course, appropriate to perform both procedures if necessary. Consult the instructor when determining which procedure to perform.)

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2. Following the procedure outlined below, service the hubs and wheel bearings on a four-wheel-drive vehicle.	___ ___ ___ ___

   a. Complete AS1-L2-UXII.

   b. Place the car securely on safety stands or lift with hoist.

   c. Using the procedure developed in item 2 of AS1-L2-UXII, disassemble the hubs and wheel bearings.

   (NOTE: It is important to mark each wheel bearing during disassembly and install it in its original position during reassembly.)

d. Clean all components.

(NOTE: Clean with safety solvent and blow dry.)

e. Inspect all components for wear or damage. Record observations.

f. Using the procedure developed in item 3 of AS1-L2-UXII, pack the wheel bearings with the appropriate grease.

g. Using the procedure developed in items 4 and 5, reassemble the hub and wheel bearings.

h. Spin the wheel and manually lock and unlock the hub to make sure no parts are binding. Record observations.

i. Road test the vehicle (with the instructor's approval) to confirm that the four-wheel-drive system is working properly. Record observations.

3. Following the procedure outlined below, service the drive shafts and universal joints on a four-wheel-drive. _ _ _ _

   a. Complete AS2-L2-UXII.

   b. Place the car securely on safety stands or lift with hoist.

   c. Using the procedure developed in item 2 of AS2-L2-UXII, remove the drive shaft from the vehicle.

   d. Replace defective or worn drive shaft components.

      (NOTE: When replacing defective or worn drive shaft components, follow either the procedures outlined in the information sheets in Lesson 2 of Unit X or the instructions that come with the U-joint press.)

   e. Using the procedure developed in item 3 of AS2-L2-UXII, install the drive shaft in the vehicle.

   f. Rotate the drive shaft and observe whether or not it moves freely. Record observations.

   g. Road test the vehicle (with instructor's approval) to confirm that the four-wheel-drive is working properly. Record observations.

Average of above evaluations* _ _ _ _

(*This average is the final evaluation for Competencies Dd5 and Dd6.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XII: FOUR-WHEEL-DRIVE OPERATION, DIAGNOSIS, AND REPAIR

UNIT XII TEST

SECTION A. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 1. When unlocked, the locking hub (on a four-wheel-drive vehicle) will receive turning power.

____ 2. In order to turn the wheels on four-wheel-drive vehicles, the steering spindle (knuckle) turns on the kingpin.

____ 3. The locking hub on four-wheel-drive vehicles may be designed to lock automatically on acceleration.

____ 4. The transfer case on four-wheel-drive vehicles is connected to the drive shaft.

____ 5. The transfer case on four-wheel-drive vehicles usually bolts directly to the front of the transmission.

____ 6. On four-wheel-drive vehicles, the shift linkage from the transfer case connects to a range-selection shifter located on the bellhousing.

____ 7. On four-wheel-drive vehicles, a drive shaft with conventional U-joints connects the transfer case to the rear differential.

____ 8. The rear differential on four-wheel-drive vehicles operates in the same manner as differentials in conventional rear-wheel-drive vehicles.

____ 9. Heavy-duty four-wheel-drive vehicles use C-clip hub and axle designs.

____ 10. Independent front-axle suspension systems use either swing axles (twin I-beams) or long/short arm suspension with ball joints connected to spindles (steering knuckles).

____ 11. Front differentials usually use leaf springs.

____ 12. Some locking mechanisms on four-wheel-drive vehicles are operated automatically by a centrifugal overrunning clutch.

____ 13. In many cases, the vehicle must be stopped in order to move the transfer case lever to the two-wheel-drive position safely.

____ 14. During two-wheel operation, gears inside the transfer case transfer driving power from the transmission output shaft (main shaft) to the rear differential drive shaft yoke at a 2 to 1 or 3 to 1 ratio.

____ 15. The rear differential in a four-wheel-drive vehicle operates exactly like those in a rear-wheel-drive vehicle during two-wheel operation.

____ 16. During two-wheel operation, the transfer case turns the front differential and drive shaft.

____ 17. During four-wheel operation, the front hubs must be locked to the axles.

____ 18. On four-wheel-drive vehicles with centrifugal overrunning clutches, hub lockup occurs automatically when the hubs and front wheels begin to turn faster than the front axles.

____ 19. During four-wheel operation, the transfer case turns both the front and rear drive shafts.

____ 20. During low-range four-wheel-drive operation, the gears inside the transfer case transfer driving power to both the rear and front differential drive shafts at a 1 to 1 gear ratio.

SECTION B. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 21. <u>Technician I</u> says that an imbalanced drive shaft may cause a vehicle to make a clanking sound while operating in four-wheel-drive.

<u>Technician II</u> says that clutch and transmission problems may cause a four-wheel-drive vehicle to make a clanking sound while operating in two-wheel-drive.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 22. <u>Technician I</u> says that, if a vehicle clicks or squeaks when backing, the technician should first make sure that the sounds are not coming from the hub caps.

<u>Technician II</u> says that tire runout may cause a vehicle to make a clanking sound while operating in two-wheel-drive.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 23. <u>Technician` I</u> says that a rear drive shaft problem will cause vibration only when the vehicle is operating in four-wheel-drive.

<u>Technician II</u> says that, if the hubs on a four-wheel-drive vehicle fail to lock, the vehicle will not operate in two-wheel-drive.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 24. Technician I says that, if the vehicle fails to operate in either two-wheel or four-wheel drive, there may be a problem with the transfer case.

Technician II says that the cruise control should never be engaged while the vehicle is on a lift rack.

Who is right?
(a) I only
(b) II only
(c) both I and II
(d) neither I nor II

____ 25. Technician I says that a catalytic converter can reach a temperature of more than 1000° Fahrenheit.

Technician II says that shock absorbers should be disconnected during differential assembly removal.

Who is right?
(a) I only
(b) II only
(c) both I and II
(d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on the Unit XII Test in order to receive an evaluation for Competencies Dd1-Dd6.)

ANSWERS TO UNIT XII TEST

1. f
2. t
3. t
4. f
5. f
6. f
7. f
8. t
9. f
10. t
11. f
12. t
13. t
14. f
15. t
16. f
17. t
18. f
19. t
20. f
21. b
22. a
23. d
24. c
25. c

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student will be able to diagnose and repair a transfer case. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and by successfully completing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student will be able to:

Lesson 1. I. Identify transfer case components and their functions (Competencies Dd1-Dd3, Part I of the Unit XIII Test).

II. Identify the operating principles of a typical chain-drive, planetary gear transfer case (Competencies Dd1-Dd3, Part I of the Unit XIII Test).

Lesson 2. I. Identify the symptoms of typical transfer case problems (Competency Dd1, Part II of the Unit XIII Test).

II. Identify safety principles in transfer case removal (Competency Dd1, Part II of the Unit XIII Test).

III. Identify the procedure for removing the transfer case (Competency Dd1, Part II of the Unit XIII Test).

Lesson 3. I. Identify the procedure for disassembling the transfer case (Competency Dd2, Part III of the Unit XIII Test).

II. Identify the procedures for cleaning and inspecting the transfer case (Competency Dd2, Part III of the Unit XIII Test).

III. Identify the source of procedures for measuring and adjusting the transfer case (Competency Dd3, Part IV of the Unit XIII Test).

IV. Identify the procedure for reassembling the transfer case (Competency Dd3, Part IV of the Unit XIII Test).

Lesson 4. I. Identify procedures for installing a transfer case (Competency Dd3, Part IV of the Unit XIII Test).

II. Identify the procedure for performance testing the transfer case (Competency Dd1, Part II of the Unit XIII Test).

III. Demonstrate the ability to:

- a. Diagnose a transfer case (Competency Dd1, JS1-L4-UXIII).

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b. Service a transfer case (Competencies Dd2 and Dd3, JS2-L4-UXIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks C073-C075, and C080.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TRANSFER CASE COMPONENTS AND HOW THEY FUNCTION
    - a. Information outline
2. Lesson 2: TRANSFER CASE DIAGNOSIS AND REMOVAL
    - a. Information outline
3. Lesson 3: TRANSFER CASE DISASSEMBLY, CLEANING, ADJUSTMENT, AND REASSEMBLY
    - a. Information outline
4. Lesson 4: TRANSFER CASE INSTALLATION AND PERFORMANCE TESTING
    - a. Information outline
    - b. Assignment sheets

      AS1-L4-UXIII: Procedure for Servicing a Transfer Case
    - c. Job sheets

      JS1-L4-UXIII: Diagnosing a Transfer Case
      JS1-L4-UXIII: Servicing a Transfer Case

E. Unit test

F. Answers to unit test

REFERENCES

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Crouse, William H., and Donald L. Anglin. Automotive Mechanics. 9th ed. New York: McGraw-Hill Book Company, 1985.

DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics: Theory and Service. Cincinnati: South-Western Publishing Co., 1986.

Gains, James R. Automotive Power Trains and Service Procedures: Instructor's Guide. Module 6 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

General Motors Corporation. 1982 Chevrolet Light Truck 10-30 Series Shop Manual. Warren, MI: Chevrolet Motor Division, General Motors Corporation, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service & Repair. San Diego: Mitchell Information Services, Inc., 1986.

Mitchell Information Services, Inc. 1986 Edition Transmission Service & Repair: Domestic Cars, Light Trucks & Vans/Imported Cars & Trucks. San Diego: Mitchell Information Services, Inc., 1986.

Stockel, Martin W., and Martin T. Stockel. Auto Mechanics Fundamentals. South Holland, Ill: Goodheart Willcox Company, Inc., 1982.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L4-UXIII in conjunction with JS2-L4-UXIII.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Safe Use of Lifting Equipment in Auto Mechanics (AM-80-100), 1980.
   2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
   3. The Principles of the Differential (AM-84-450), 1984.
   4. Axle Bearing and Seal Replacement (AM-84-452), 1984.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

LESSON 1: TRANSFER CASE COMPONENTS AND HOW THEY FUNCTION

I. Transfer case components and functions

- A. Case
    - 1. The transfer case itself is cast of either iron or aluminum in two pieces.
    - 2. The front half of the transfer case is drilled and machined so that it can be mated to the transmission extension housing, which is specially made for four-wheel-drive vehicles.
- B. Input shaft or gear
    - 1. The input shaft or gear brings the power to the transfer case from the transmission main (output) shaft. Splines provide a connection between these shafts.
    - 2. The input shaft or gear is supported in the case by a ball bearing or roller bearing on the front of the output shaft (main shaft).
- C. Output shaft (main shaft) assembly
    - 1. The output shaft is supported in front by roller bearings and at the back of the case by roller or ball bearings.
    - 2. The output shaft uses a helical gear and engagement clutches or a planetary gear assembly.
    - 3. The rear of the output shaft is splined and connects with the slip yoke of the rear drive shaft assembly.
- D. Drive chain or idler gear and shaft assembly
    - 1. Most transfer cases use a chain and sprockets to relay turning power to the front output shaft assembly.
    - 2. Some transfer cases, however, use two helical gears, one on the rear output shaft (main shaft) and the other on the front output shaft.
- E. Front output shaft
    - 1. The front output shaft is supported in the case at both ends by bearings (which are in the case).
    - 2. The shaft is splined to engage the yoke on the front differential drive shaft.

F. Shift forks and rails

1. Shift forks straddle the grooves of synchronizer sleeves. The forks allow the synchronizer sleeves or gears to be slid into engagement.

2. The shift forks are on rails. The rails allow the forks to move back and forth through a system of levers and detents.

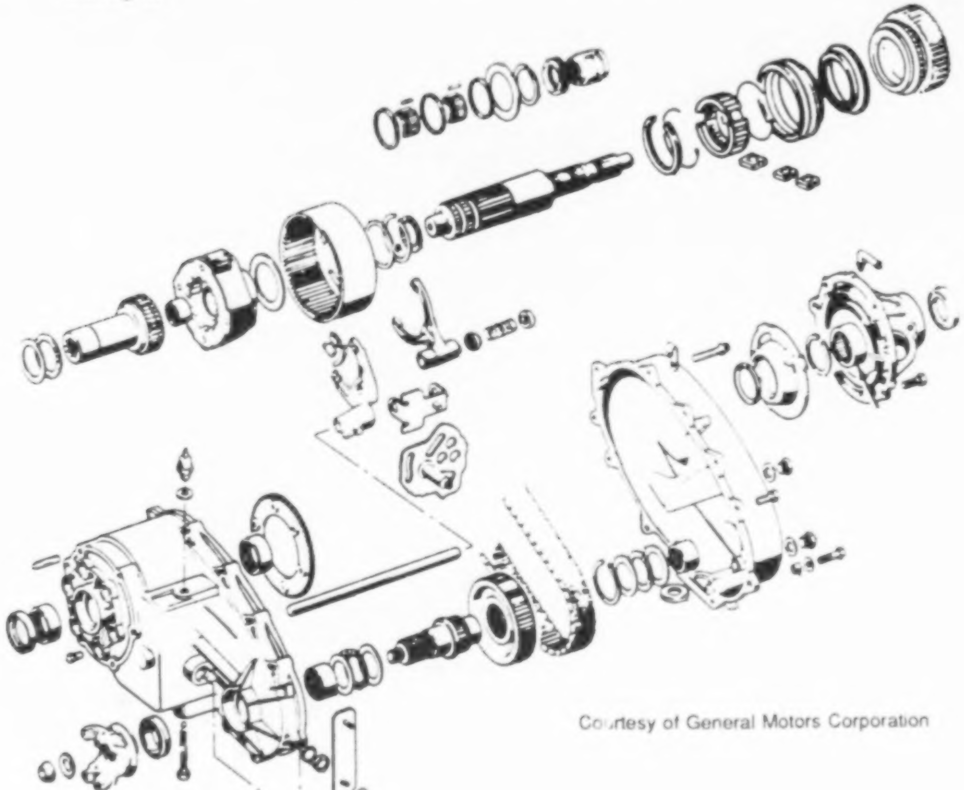
G. Lubrication

1. Depending on their design, transfer cases use either gear lube or automatic transmission fluid. Refer to manufacturer's recommendations for the correct type and quantity of lubricant to be used.

2. In some transfer case designs, the spinning of the gears splashes lubricant on the bearings, gears, and the chain. In other designs a pump, driven by the output (main) shaft, provides lubricant to the appropriate locations.

3. Neoprene rubber seals prevent lubricant leakage.

H. A light in the vehicle's interior indicates that the vehicle is operating in four-wheel-drive. On most vehicles, an electrical sensor in the transfer case activates this light.



Courtesy of General Motors Corporation

TRANSFER CASE (EXPLODED VIEW)

II. Transfer case operation (typical chain drive, planetary gear type)

A. Turning power enters the transfer case through the input shaft or gear, which is splined to the transmission main shaft (output shaft).

B. Case operation while vehicle is in neutral

   1. The annulus gear (ring gear) is not engaged to the rear output shaft (main shaft).
   2. The input gear (sun gear) turns the planet gears.
   3. The planet gears drive the annulus gear (ring gear) which spins freely.
   4. No power is transferred.

C. Case operation while vehicle is in the two-wheel-drive, high range

   1. The rear output shaft (main shaft) is connected to the annulus gear (ring gear).
   2. The planetary carrier is also splined to the rear output shaft.
   3. The input gear (sun gear) turns the planet gear.
   4. Since the planetary carrier and the annulus gear are connected to the rear output shaft, they must turn together.
   5. The input shaft and gear spin the entire planetary unit, along with the rear output shaft at the same speed.
   6. The rear output shaft is splined to the rear drive shaft slip yoke Thus the yoke turns the drive shaft, differential, and the rear wheels.

D. Case operation while vehicle is in the neutral four-wheel-drive, high range

   1. The synchronizer sleeve on the rear output shaft is slid into engagement with the chain-drive sprocket.
   2. The drive sprocket turns the drive chain
   3. The drive chain turns the driven sprocket on the front output shaft.
   4. The driven sprocket is splined to the front output shaft; therefore, the driven sprocket turns the shaft.
   5. The front output shaft is splined to the front drive shaft yoke.
   6. At this time both the front and rear drive shafts are turning
   7. The front drive shaft drives the front differential and (if the hubs are locked) the front wheels.

E. Case operation while vehicle is in the four-wheel-drive, low range

1. The synchronizer sleeve (clutch sleeve) remains engaged to the drive sprocket, allowing the vehicle to remain in the four-wheel-drive mode.

2. The annulus gear (ring gear) is slid out of engagement with the rear output shaft and into engagement with a stationary lockup gear plate bolted to the front case half.

3. The input gear (sun gear) spins the planet gears.

4. Since the annulus gear (ring gear) cannot move, the spinning of the planet gears causes the planet carrier to turn at a slower speed.

5. The planet carrier is splined to the rear output shaft (main shaft), which is also turned at the slower speed. This is a low gear ratio (about 2 to 1).

6. The front output shaft is also turned at this slower speed by way of the drive chain and sprockets.

7. Driving power is delivered through both drive shafts and differentials to all four wheels at a low ratio.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

LESSON 2: TRANSFER CASE DIAGNOSIS AND REMOVAL

I. The exact procedure for the diagnosis of transfer case problems depends upon the design of the particular model that is being serviced. The following chart is typical of chain-drive, planetary transfer cases. Refer to the appropriate manual for information specific to the model that is being serviced.

Service Diagnosis

Condition	Possible Cause	Correction
TRANSFER CASE DIFFICULT TO SHIFT OR WILL NOT SHIFT INTO DESIRED RANGE	(1) Vehicle speed too great to permit shifting.	(1) Stop vehicle and shift into desired range. Or reduce speed to 2-3 mph (3-4 km/h) before attempting to shift.
	(2) If vehicle was operated for extended period in 4H mode on dry paved surface, driveline torque load may cause difficult shifting.	(2) Stop vehicle, shift transmission to neutral, shift transfer case to 2H mode and operate vehicle in 2H on dry paved surfaces.
	(3) Transfer case external shift linkage binding.	(3) Lubricate or repair or replace linkage, or tighten loose components as necessary.
	(4) Insufficient or incorrect lubricant.	(4) Drain and refill to edge of fill hole with DEXRON®-II only.
	(5) Internal components binding, worn, or damaged.	(5) Disassemble unit and replace worn or damaged components as necessary.
TRANSFER CASE NOISY IN ALL DRIVE MODES	(1) Insufficient or incorrect lubricant.	(1) Drain and refill to edge of fill hole with DEXRON®-II only. Check for leaks and repair if necessary. Note: If unit is still noisy after drain and refill, disassembly and inspection may be required to locate source of noise.
NOISY IN — OR JUMPS OUT OF FOUR WHEEL DRIVE LOW RANGE	(1) Transfer case not completely engaged in 4L position.	(1) Stop vehicle, shift transfer case in Neutral, then shift back into 4L position.
	(2) Shift linkage loose or binding.	(2) Tighten, lubricate, or repair linkage as necessary.
	(3) Range fork cracked, inserts worn, or fork is binding on shift rail.	(3) Disassemble unit and repair as necessary.
	(4) Annulus gear or lockplate worn or damaged.	(4) Disassemble unit and repair as necessary.
LUBRICANT LEAKING FROM OUTPUT SHAFT SEALS OR FROM VENT	(1) Transfer case overfilled.	(1) Drain to correct level.
	(2) Vent closed or restricted.	(2) Clear or replace vent if necessary.
	(3) Output shaft seals damaged or installed incorrectly.	(3) Replace seals. Be sure seal lip faces interior of case when installed. Also be sure yoke seal surfaces are not scored or nicked. Remove scores, nicks with fine sandpaper or replace yoke(s) if necessary.
ABNORMAL TIRE WEAR	(1) Extended operation on dry hard surface (paved) roads in 4H range.	(1) Operate in 2H on hard surface (paved) roads.

Courtesy of General Motors Corporation

II. Safety in transfer case removal

A. Since the technician must work underneath the vehicle to remove the transfer case, the vehicle must be properly supported on jackstands or a hydraulic lift rack. Refer to manufacturer's recommendations for safe locations of lift or jackstands.

B. Falling debris from the underside of the vehicle is a hazard; therefore, safety glasses or goggles must always be worn.

C. The transfer case may weigh over 100 pounds; therefore, the technician must plan carefully before lowering the transfer case from the vehicle. A jack may be required to lower the transfer case.

D. A transfer case is cast of iron or aluminum and may have sharp edges, which can cut the technician. When handling the case, the technician should wear protective gloves. Consult the instructor before attempting to remove a transfer case from a vehicle.

III. Procedures for removing the transfer case

A. Place selector lever in four-wheel-drive, high range.

B. Place the car securely on safety stands or lift with hoist.

C. Drain lubricant from transfer case.

D. Disconnect shaft linkage.

E. Mark both output shaft and drive shaft yokes for reference.

F. Disconnect all wires and cables (including the speedometer cable).

G. Remove front and rear drive shafts. Wrap U-joints with tape.

(NOTE: Never allow a drive shaft to hang by the differential.)

H. Remove any remaining parking brake cables or struts as required.

I. Place a jack or some other form of support under the transfer case, and remove the bolts holding the case to the transmission extension housing.

J. Place a jack under the transfer case and slide the case assembly toward the front of the vehicle until it can be lowered with a jack.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

LESSON 3: TRANSFER CASE DISASSEMBLY, CLEANING, ADJUSTMENT, AND REASSEMBLY

I. Procedure for disassembly of transfer case

(NOTE: Exact procedures for the disassembly of the transfer case vary, depending on the particular model of vehicle that is being serviced. Refer to an appropriate manual for correct disassembly procedures.)

A. Remove fill and drain plugs.

B. Remove front and rear drive shaft yokes. Discard old nuts and seals.

C. Support transfer case on end with wooden blocks.

D. Remove mode indicator sensor and related hardware.

E. Mark and remove rear bearing retainer and oil pump as an assembly.

F. Mark and remove pump housing and seal from bearing retainer housing.

G. Remove case half bolts and remove rear case.

H. Remove front output shaft rear thrust bearing assembly. Mark position of bearing and races for reassembly.

I. Remove driven and drive sprocket snap rings and thrust washers.

J. Remove sprockets and drive chain together.

(NOTE: The transfer case may contain needle bearings, which will fall out during this stage of the disassembly procedure. Be sure to collect all needle bearings.)

K. Remove front output shaft front thrust bearing assembly.

L. Refer to manual for removal of synchronizer assemblies, sliding clutches, shift forks and rails, planetary gear set, thrust washers, needle bearings, front and rear output shafts.

M. Remove output shaft seals.

II. Procedures for cleaning and inspecting the transfer case

A. Scrape gasket material from transmission extension housing and transfer case halves.

B. Wash all parts in cleaning solvent. Dry with compressed air.

C. Clean oil passages with compressed air.

D. Check all gear teeth and splines for burrs, nicks, and excessive wear or damage.

E. Inspect all snap rings and thrust washers for wear or distortion.

F. Inspect case halves for cracks, damaged mating surfaces, and defective threaded holes.

G. Check lock plate teeth and hub for cracks, chips, or excessive wear.

H. Check bearing by applying oil and turning by hand. Replace the bearing if it is rough, corroded, scratched, or burned.

I. Inspect loose needle bearings for wear or damage.

J. Inspect bearing bores in case halves for damage or wear.

K. Inspect input shaft, rear output shaft, and front output shaft for damage or wear.

L. Inspect shift forks and rails for wear.

M. Inspect drive chain for stretching or wear. Inspect sprockets for damaged or worn teeth.

N. Replace all defective components as required.

III. Transfer case assemblies are extremely durable and require few critical measurements during assembly. Refer to the service manual for any required end play or turning torque measurements.

IV. Procedures for the reassembly of transfer cases vary widely depending on the model of vehicle that is being serviced. The following procedures are common to transfer case assembly. Refer to the service manual for exact assembly procedures for the vehicle being serviced.

A. Transfer cases are put together as sub-assemblies. These sub-assemblies must be put together in the exact sequence specified in the service manual. Below are some examples of transfer case sub-assemblies.

1. Shift rail and fork assembly

2. Front output shaft and gear assembly

3. Rear output shaft assembly

4. Drive chain and sprocket assembly

B. All parts are lubricated during assembly. Automatic transmission fluid is often specified for gears and shafts. Petroleum jelly may be used when packing bearings.

C. Special driver tools must be used when installing bearings and seals.

D. Bolts must always be torqued to an exact specification as listed in the service manual.

E. New gaskets must be used during the assembly. In some instances, case halves and seals may be sealed with special silicone or anaerobic sealers.

F. New self-locking nuts are usually specified for output shaft yokes.

G. All marked components must be realigned during assembly.

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

LESSON 4: TRANSFER CASE INSTALLATION AND PERFORMANCE TESTING

I. Transfer case installation

  A. Install transmission extension housing to transfer case gasket on transmission.

  B. Shift transfer case to four-wheel-drive, high-range position (4H).

  C. Raise transfer case into position and move it toward the transmission.

  D. Engage splines of input shaft with transmission main shaft (output shaft) by turning one of the drive shaft yokes on the transfer case.

  E. Slide transfer case securely against the transmission extension housing. Start a couple of bolts to hold in position.

  F. Start the remaining bolts and tighten with torque wrench to manufacturer's specification.

  (NOTE: The transfer case must be in complete contact with the transmission extension housing prior to tightening the bolts or severe damage to the case will result.)

  G. Connect speedometer driven gear to transfer case.

  H. Connect front and rear drive shafts to transfer case output shaft yokes. Be sure U-joints are properly positioned and the U-bolts are tightened evenly.

  I. Remove jack or support from under transfer case.

  J. Connect all previously disconnected cables, wires, and struts.

  K. Install frame mount bolts and tighten to specification.

  L. Connect shift linkage and adjust. Refer to manual for correct adjustment procedures.

  M. Fill transfer case to level with lubricant suggested by the manufacturer.

II. Procedure for performance testing the transfer case

  A. Shift transfer case into neutral position.

  B. Start engine and slowly release clutch pedal. Note any unusual noises. Refer to trouble shooting chart as required.

  C. Shift transmission to neutral and transfer case to two-wheel-drive, high range (2H). Shift transmission to first gear.

D. Slowly release clutch pedal and note any unusual noises.

E. Repeat steps C and D for four-wheel-drive, high range (4H) and four-wheel-drive, low range (4L).

F. Refer to trouble shooting chart as required.

G. Check underneath vehicle for lubricant leaks. Repair as required.

H. After obtaining the approval of the instructor, drive the vehicle normally at low speed in all driving modes. Also drive vehicle at highway speeds and note any unusual vibrations or sounds. Refer to trouble shooting chart as required.

MODULE: MANUAL DRIVE TRAIN AND AXLES

PROCEDURE FOR SERVICING A TRANSFER CASE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the transfer case from the vehicle to be serviced.
3. Develop a written procedure for disassembling the transfer case.
4. Determine and record critical dimensions or clearances relating to transfer case components. Develop a written procedure for checking each of these critical dimensions or clearances.
5. Write out the sequence in which the transfer case components will be reassembled.
6. Determine and record all torque specifications related to the transfer case.
7. Determine and record the type and quantity of fluid needed to refill transfer case.
8. Develop a written procedure for reinstalling the transfer case. Include appropriate torque specifications.
9. Develop a written procedure for adjusting the linkage.
10. Develop a written procedure for aligning power train mounts.

JS1-L4-UXIII

MODULE: MANUAL DRIVE TRAIN AND AXLES

DIAGNOSING A TRANSFER CASE

Equipment:

Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, performance test a vehicle equipped with a four-wheel-drive transfer case. ___ ___ ___ ___

   a. Start vehicle (with the instructor's approval) and drive slowly in each of the transfer case gear ranges. Note any grinding, grabbing, slipping, or other unusual activity or noise. Record observations.

   b. According to the performance test, is the four-wheel-drive system operating properly?

   Yes ______ No ______

   c. If no, explain steps that should be taken to correct the situation.

   Average of above evaluations* ___ ___ ___ ___

   (*This average is a partial evaluation for Competency Dd1. Final evaluation for Dd1 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Dd1 by averaging the final evaluation of JS1-L2-UXII and JS1-L4-UXIII. Use the spaces provided below.

JS1-L2-UXII ___ ___ ___ ___

JS1-L4-UXIII ___ ___ ___ ___

Final evaluation for Competency Dd1 ___ ___ ___ ___

JS2-L4-UXIII

MODULE: MANUAL DRIVE TRAIN AND AXLES

SERVICING A TRANSFER CASE

Equipment:

Hand tools
Hoist
Serviceable vehicle
Transmission jack
Snap ring pliers
Drain pan
Special tools as outlined in AS1-L4-UXIII
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Complete items 1 and 2 of AS1-L4-UXIII. ___ ___ ___ ___

2. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

3. Place the car securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Remove the negative battery cable before raising the vehicle.)

4. Following the procedure developed in item 2 of AS1-L1-UXIII, remove the transfer case. Have the instructor approve the removal procedure before starting. ___ ___ ___ ___

5. Following the procedure outlined below, disassemble the transfer case. ___ ___ ___ ___

   a. Complete item 3 of AS1-L4-UXIII.

   b. Inspect the transfer case for leakage. Record observations.

c. Drain the fluid from the transfer case. Note the condition of the fluid. Record observations.

d. Using the procedure developed in items 3 and 4 of AS1-L4-UXIII, disassemble the transfer case.

e. Clean transfer case components and case.

(NOTE: Clean with safety solvent and blow dry.)

6. Inspect all transfer case components for damage. Record observations. — — — —

(HINT: Refer to item 4 of AS1-L4-UXIII for transmission specifications.)

7. Following the procedure outlined below, reassemble the transfer case. — — — —

   a. Be sure that gasket material is completely removed from case, housing, side plate, and input shaft bearing retaining collar.

   b. Be sure that all damaged or missing parts have been replaced as directed by the instructor.

   c. Complete items 5 and 6 of AS1-L4-UXIII.

   d. Using the procedure developed in items 5 and 6 of AS1-L4-UXIII, reassemble the transfer case.

      (NOTE: During reassembly, lightly coat all gears and bearings with the appropriate fluid.)

   e. Bench test the transfer case to make sure that it works freely in all gears and shifts smoothly into all gears. Record observations.

8. Following the procedure outlined below, reinstall the transfer case. — — — —

   a. Complete items 7, 8, 9, and 10 of AS1-L4-UXIII.

   b. Using the procedure developed in items 8, 9, and 10 of AS1-L4-UXIII, reinstall the transfer case.

c. Torque mounting bolts and linkage mounting bolts to the specifications given in the service manual.

d. Install the drive shafts.

e. Fill transfer case with fluid. Fill to the correct level.

9. Following the procedure outlined below, performance test the vehicle which has just undergone transfer case service. ____

a. Start the vehicle (with the instructor's approval) and drive slowly in each of the transfer case gear ranges. Note any grinding, grabbing, slipping or other unusual noise or activity. Record observations.

b. Recheck fluid level. Add fluid as necessary.

Average of above evaluations* ____

(*This average is the final evaluation for Competencies Dd2 and Dd3.)

MODULE: MANUAL DRIVE TRAIN AND AXLES

UNIT XIII: TRANSFER CASE DIAGNOSIS AND REPAIR

UNIT XIII TEST

PART I. TRANSFER CASE COMPONENTS AND HOW THEY FUNCTION

SECTION A. Select the best answer from the five choices listed.

____ 1. In four-wheel-drive vehicles, the transfer case is cast in

- a. one piece.
- b. two pieces.
- c. three pieces.
- d. four pieces.
- e. five pieces.

____ 2. The input shaft or gear brings the power into the transfer case from

- a. the transaxle.
- b. the differential.
- c. the transmission main shaft.
- d. the first speed gear.
- e. none of the above.

____ 3. In the transfer case, the input shaft or gear is supported in the case by

- a. a bearing at the front and by roller bearings on the front of the output shaft (main shaft).
- b. a bushing at the front and by roller bearings on the front of the output shaft (main shaft).
- c. a bearing at the front and by a bushing on the front of the output shaft (main shaft).
- d. bushings both at the front and on the front of the output shaft.
- e. none of the above.

____ 4. In order to relay turning power to the front output shaft assembly, many transfer cases use

- a. a single drive shaft.
- b. two drive shafts and a linkage.
- c. a fork shaft.
- d. a silent chain and sprockets.
- e. none of the above.

____ 5. In the transfer case, shift forks straddle the grooves of

- a. synchronizer sleeves.
- b. range fork pads.
- c. range selector shafts.
- d. all of the above.
- e. none of the above.

____ 6. For lubrication, transfer cases use

a. automatic transmission fluid only.
b. gear lube only.
c. either gear lube or automatic transmission fluid.
d. petroleum jelly.
e. none of the above.

____ 7. In some transfer case designs, the spinning of the gears splashes lubricant on the bearings, gears, and chain. In other designs, lubricant is applied to these components by

a. a pump.
b. rubber boots, which secrete small amounts of grease during operation.
c. hand, as a part of regularly scheduled maintenance.
d. any of the above methods.
e. none of the above methods.

SECTION B. **Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.**

____ 8. Turning power enters the transfer case through the input shaft or gear, which is attached to the transmission main shaft by a flexible linkage (output shaft).

____ 9. While the vehicle is in neutral, the input gear (sun gear) turns the planet gears in the transfer case.

____ 10. During two-wheel-drive, high range operation, the input shaft and gear spin the entire planetary unit in the transfer case.

____ 11. During four-wheel-drive, low-range operation, the synchronizer sleeve (clutch sleeve) in the transfer case remains engaged to the drive sprocket, allowing the vehicle to remain in four-wheel-drive.

____ 12. During four-wheel-drive, low-range operation, the planet carrier and the rear output shaft operate at about a 4 to 1 ratio.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XIII Test in order to receive an evaluation for Competencies Dd1-Dd3.)

PART II. DIAGNOSING AND REMOVING THE TRANSFER CASE

SECTION A. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 13. Technician I says that, if a vehicle is operated for an extended period in the four-wheel-drive mode on a dry paved surface, the driveline torque load may make shifting difficult.

Technician II says that lubricant leaking from output shaft seals may be the result of too much lubricant in the transfer case.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 14. Technician I says that, if the vehicle jumps out of four-wheel-drive low range, the transfer case external shift linkage may be binding.

Technician II says that binding of internal transfer case components can cause enough vibration to cause tires to wear abnormally.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 15. Technician I says that, if a four-wheel-drive vehicle is noisy during all modes of operation, the transfer case may contain insufficient or improper lubricant.

Technician II says that lubricant leaking from output shaft seals may be caused by a closed or restricted vent on the transfer case.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 16. Technician I says that, if the transfer case is operating properly, extended operation on dry, hard roads should not result in abnormal tire wear.

Technician II says that, if a vehicle is noisy during four-wheel-drive, low-range operation, the transfer case may not be completely engaged in the 4L position.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. Technician I says that the vehicle should be in two-wheel-drive during transfer case removal.

Technician II says that all wires and cables (including the speedometer cable) should be removed from the transfer case when the case is taken out of the vehicle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 18. Technician I says that a drive shaft should never be allowed to hang by the differential during transfer case removal.

Technician II says that, when the transfer case is free of all restricting components, the case should be slid toward the front of the vehicle until it can be lowered with a jack.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XIII Test in order to receive an evaluation for Competency Dd1.)

PART III. DISASSEMBLING, CLEANING, AND ADJUSTING THE TRANSFER CASE

SECTION A. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 19. Oil passages within the transfer case should be cleaned with compressed air.

____ 20. All transfer case parts should be cleaned in solvent and blow dried with compressed air.

____ 21. When disassembling a transfer case, the technician should plan to reuse nuts and seals from drive shaft yokes if they do not exhibit excessive damage.

____ 22. During transfer case disassembly, the rear bearing retainer and oil pump should each be removed separately.

____ 23. During transfer case disassembly, the sprockets and drive chain should be removed together.

(NOTE: The student must obtain a minimum score of ____ on Part III of the Unit XIII Test in order to receive an evaluation for Competency Dd2.)

PART IV. ASSEMBLING, ADJUSTING, AND PERFORMANCE TESTING THE TRANSFER CASE

SECTION A. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 24. Though they are heavy and apparently sturdy, transfer case assemblies require many critical measurements during assembly.

____ 25. Transfer case reassembly involves putting together several sub-assemblies.

____ 26. During assembly, petroleum jelly is often used for lubricating gears and shafts.

____ 27. New gaskets must be installed in the transfer case during assembly.

____ 28. If, during installation, the transfer case does not completely contact the transmission extension housing before the bolts are tightened, severe damage to the case can result.

(NOTE: The student must obtain a minimum score of ____ on Part IV of the Unit XIII Test in order to receive an evaluation for Competency Dd3.)

ANSWERS TO UNIT XIII TEST

1. a
2. c
3. a
4. d
5. a
6. c
7. a
8. f
9. t
10. t
11. t
12. f
13. c
14. a
15. c
16. b
17. b
18. c
19. t
20. t
21. f
22. f
23. t
24. f
25. t
26. f
27. t
28. t